

## PATENT COOPERATION TREATY

## PCT

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference <b>P. 5897. WOP</b>	<b>FOR FURTHER ACTION</b> see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. <b>PCT/GB 00/ 00801</b>	International filing date (day/month/year) <b>09/03/2000</b>	(Earliest) Priority Date (day/month/year) <b>10/03/1999</b>
Applicant  <b>NEW TRANSDUCERS LIMITED</b>		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 4 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

## 1. Basis of the report

- a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of Invention is lacking** (see Box II).

4. With regard to the **title**,

☐ the text is approved as submitted by the applicant.

☒ the text has been established by this Authority to read as follows:

**RESONANT-MODE PANEL LOUDSPEAKER WITH LIGHT EMITTER**

5. With regard to the **abstract**,

☐ the text is approved as submitted by the applicant.

☒ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

☒ as suggested by the applicant.

☐ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

1  
☐ None of the figures.

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/GB 00/00801

## Box III TEXT OF THE ABSTRACT (Continuation of item 5 of the first sheet)

A combination panel-form loudspeaker/light comprising a panel (12) having a front face (14) and rear face (16), a vibration exciter (18,20) mounted to the member to excite bending-wave vibration in the member, and a light emitter (22) mounted at or adjacent to the panel and arranged to illuminate an area adjacent to the panel.

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 00/00801

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H04R1/02

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H04R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 97 09840 A (AZIMA HENRY ;HARRIS NEIL (GB); COLLOMS MARTIN (GB); VERITY GROUP P) 13 March 1997 (1997-03-13) page 6, line 5 -page 8, line 12 page 11, line 27 -page 14, line 1; figures 2A,2B,4,5	1-3,9, 11,12
Y	-----	4-7,10, 13,14
Y	US 4 559 584 A (KUWAHATA TOSHIKATSU ET AL) 17 December 1985 (1985-12-17) the whole document	4-7,10
Y	-----	4-7,10
Y	FR 2 649 575 A (THOMSON CONSUMER ELECTRONICS) 11 January 1991 (1991-01-11) page 2, line 23 -page 6, line 18; figures 1-6	
	-----	
	-/--	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

\* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

29 June 2000

Date of mailing of the international search report

11/07/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
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Authorized officer

Nieuwenhuis, P

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 00/00801

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 97 09843 A (AZIMA HENRY ;HARRIS NEIL (GB); COLLOMS MARTIN (GB); VERITY GROUP P) 13 March 1997 (1997-03-13) page 6, line 8 -page 8, line 15 page 11, line 16 -page 13, line 13; figures 2A,2B,3A,3B -----	13,14
A	US 4 820 952 A (LEE KYE S) 11 April 1989 (1989-04-11) the whole document -----	1
P,X	WO 99 65274 A (NEW TRANSDUCERS LTD ;BANK GRAHAM (GB)) 16 December 1999 (1999-12-16) the whole document -----	1,3

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 00/00801

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 9709840	A	13-03-1997	AT 177579 T	15-03-1999
			AT 177574 T	15-03-1999
			AT 177580 T	15-03-1999
			AT 177575 T	15-03-1999
			AT 186617 T	15-11-1999
			AT 177581 T	15-03-1999
			AT 177582 T	15-03-1999
			AT 177583 T	15-03-1999
			AT 177578 T	15-03-1999
			AT 177576 T	15-03-1999
			AT 179297 T	15-05-1999
			AT 177577 T	15-03-1999
			AT 179563 T	15-05-1999
			AT 176826 T	15-03-1999
			AT 179045 T	15-04-1999
			AT 179296 T	15-05-1999
			AT 177281 T	15-03-1999
			AT 179564 T	15-05-1999
			AT 177282 T	15-03-1999
			AT 179043 T	15-04-1999
			AT 179044 T	15-04-1999
			AU 702865 B	11-03-1999
			AU 6880196 A	27-03-1997
			AU 702920 B	11-03-1999
			AU 6880296 A	27-03-1997
			AU 702867 B	11-03-1999
			AU 6880396 A	27-03-1997
			AU 703015 B	11-03-1999
			AU 6880496 A	27-03-1997
			AU 702863 B	11-03-1999
			AU 6880596 A	27-03-1997
			AU 702873 B	11-03-1999
			AU 6880696 A	27-03-1997
			AU 702999 B	11-03-1999
			AU 6880796 A	27-03-1997
			AU 703061 B	11-03-1999
			AU 6880896 A	27-03-1997
			AU 703000 B	11-03-1999
			AU 6880996 A	27-03-1997
			AU 703071 B	11-03-1999
			AU 6881096 A	27-03-1997
			AU 703058 B	11-03-1999
			AU 6881296 A	27-03-1997
			AU 705592 B	27-05-1999
			AU 6881396 A	27-03-1997
			AU 703296 B	25-03-1999
			AU 6881496 A	27-03-1997
			AU 699890 B	17-12-1998
			AU 6881596 A	27-03-1997
			AU 703198 B	18-03-1999
US 4559584	A	17-12-1985	NONE	
FR 2649575	A	11-01-1991	NONE	
WO 9709843	A	13-03-1997	AT 177579 T	15-03-1999
			AT 177574 T	15-03-1999
			AT 177580 T	15-03-1999

# INTERNATIONAL SEARCH REPORT

Information on patent family members

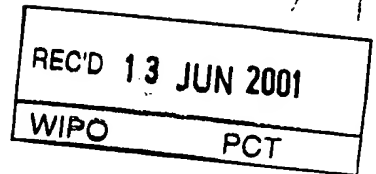
International Application No

PCT/GB 00/00801

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9709843 A		AT 177575 T	15-03-1999
		AT 186617 T	15-11-1999
		AT 177581 T	15-03-1999
		AT 177582 T	15-03-1999
		AT 177583 T	15-03-1999
		AT 177578 T	15-03-1999
		AT 177576 T	15-03-1999
		AT 179297 T	15-05-1999
		AT 177577 T	15-03-1999
		AT 179563 T	15-05-1999
		AT 176826 T	15-03-1999
		AT 179045 T	15-04-1999
		AT 179296 T	15-05-1999
		AT 177281 T	15-03-1999
		AT 179564 T	15-05-1999
		AT 177282 T	15-03-1999
		AT 179043 T	15-04-1999
		AT 179044 T	15-04-1999
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		AU 6881096 A	27-03-1997
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		AU 705592 B	27-05-1999
		AU 6881396 A	27-03-1997
		AU 703296 B	25-03-1999
		AU 6881496 A	27-03-1997
		AU 699890 B	17-12-1998
		AU 6881596 A	27-03-1997
		AU 703198 B	18-03-1999
US 4820952 A	11-04-1989	DE 3731132 A	24-03-1988
WO 9965274 A	16-12-1999	AU 4156999 A	30-12-1999

## PATENT COOPERATION TREATY

## PCT



## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference P.5897.WOP	<b>FOR FURTHER ACTION</b> See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/GB00/00801	International filing date (day/month/year) 09/03/2000	Priority date (day/month/year) 10/03/1999
International Patent Classification (IPC) or national classification and IPC H04R1/02		
Applicant NEW TRANSDUCERS LIMITED		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.



2. This REPORT consists of a total of 5 sheets, including this cover sheet.

- ☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☒ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand  06/09/2000	Date of completion of this report  11.06.2001
Name and mailing address of the international preliminary examining authority:   European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer  Nieuwenhuis, P  Telephone No. +49 89 2399 8968 

# INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/00801

## I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

**Description, pages:**

1-8 as originally filed

**Claims, No.:**

1-14 as originally filed

**Drawings, sheets:**

1/4-4/4 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**

International application No. PCT/GB00/00801

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

*(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)*

6. Additional observations, if necessary:

**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Yes:	Claims	1-14
	No:	Claims	
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-14
Industrial applicability (IA)	Yes:	Claims	1-14
	No:	Claims	

2. Citations and explanations  
**see separate sheet**

**VII. Certain defects in the international application**

The following defects in the form or contents of the international application have been noted:  
**see separate sheet**

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT - SEPARATE SHEET**

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International application No. PCT/GB00/00801

**Re Item V**

**Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Reference is made to the following documents:

- D1: WO 97 09840 A (AZIMA HENRY ;HARRIS NEIL (GB); COLLOMS MARTIN (GB); VERITY GROUP P) 13 March 1997 (1997-03-13)
- D2: US-A-4 559 584 (KUWAHATA TOSHIKATSU ET AL) 17 December 1985 (1985-12-17)
- D3: FR-A-2 649 575 (THOMSON CONSUMER ELECTRONICS) 11 January 1991 (1991-01-11)
- D4: WO 97 09843 A (AZIMA HENRY ;HARRIS NEIL (GB); COLLOMS MARTIN (GB); VERITY GROUP P) 13 March 1997 (1997-03-13)

2. Claim 1 in its broadest sense merely relates to a distributed mode loudspeaker known from e.g. D1 and which is placed near an ordinary light emitter (e.g. fluorescent tube or light bulb) not showing any inventive working interrelationship with the emitter (see also PCT Guidelines 3-IV,8.8, B1). Consequently the subject-matter of these claims is not inventive.
3. Dependent claims 2-14 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty and/or inventive step, the reasons being as follows:

**Regarding claims 2 and 3:** See comments given with respect to claim 1.

**Regarding claims 4-8,10:** To mount light emitters within a loudspeaker cavity and behind the loudspeaker membrane is known from e.g. D2 and D3. To additionally direct to light to where it is desired and take the straightforward necessary steps to achieve this, as presently claimed in claims 4-8, lies within the scope of the customary practice followed by persons skilled in the art, especially as the advantages thus achieved can readily be foreseen.

**Regarding claims 11 and 12:** The additional mechanical protection of a loudspeaker diaphragm extending beyond its perimeter is standard practice. The mere choice of an opaque cover does not involve any inventive activity.

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT - SEPARATE SHEET**

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International application No. PCT/GB00/00801

**Regarding claims 13 and 14: See D4.**

**Re Item VII**

**Certain defects in the international application**

1. The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).
2. Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the documents D2 and D3 are not mentioned in the description, nor are these documents identified therein.
3. By mixing the use of the terms "panel" and "member" for the same item (see e.g. claim 1), the requirement that terminology should be consistent throughout the international application (cf. Rule 10.2 PCT) is not met.

## PATENT COOPERATION TREATY

RECEIVED

10 AUG 2001

From the  
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

PCT

To:	DUE DATE:	N/A
ROLLINS, A.	FORMALITIES:	JH
NYCOMED AMERSHAM PLC	PAT. OFF:	IJF
Amersham Laboratories	ON DB:	10/8/01
White Lion Road	CASE NO:	PA9902
Amersham, Bucks HP7 9LL		
GRANDE BRETAGNE		

NOTIFICATION OF TRANSMITTAL OF  
THE INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT  
(PCT Rule 71.1)Date of mailing  
(day/month/year) 07.08.2001Applicant's or agent's file reference  
PA9902

## IMPORTANT NOTIFICATION

International application No.  
PCT/GB00/00807International filing date (day/month/year)  
09/03/2000Priority date (day/month/year)  
12/03/1999Applicant  
AMERSHAM PHARMACIA BIOTECH UK LTD. et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.
2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.


## 4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/



European Patent Office  
D-80298 Munich  
Tel. +49 89 2399 - 0 Tx: 523656 epmu d  
Fax: +49 89 2399 - 4465

Authorized officer

Danti, B

Tel. +49 89 2399-8161




# PATENT COOPERATION TREATY

## PCT

### INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference <b>PA9902</b>		<b>FOR FURTHER ACTION</b> See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. <b>PCT/GB00/00807</b>	International filing date (day/month/year) <b>09/03/2000</b>	Priority date (day/month/year) <b>12/03/1999</b>	
International Patent Classification (IPC) or national classification and IPC <b>C12Q1/68</b>			
Applicant <b>AMERSHAM PHARMACIA BIOTECH UK LTD. et al.</b>			
<p>1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 7 sheets, including this cover sheet.</p> <p><input checked="" type="checkbox"/> This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).</p> <p>These annexes consist of a total of 4 sheets.</p>			
<p>3. This report contains indications relating to the following items:</p> <ul style="list-style-type: none"> <li>I <input checked="" type="checkbox"/> Basis of the report</li> <li>II <input type="checkbox"/> Priority</li> <li>III <input type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</li> <li>IV <input type="checkbox"/> Lack of unity of invention</li> <li>V <input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</li> <li>VI <input checked="" type="checkbox"/> Certain documents cited</li> <li>VII <input type="checkbox"/> Certain defects in the international application</li> <li>VIII <input type="checkbox"/> Certain observations on the international application</li> </ul>			
Date of submission of the demand  <b>06/10/2000</b>		Date of completion of this report  <b>07.08.2001</b>	
Name and mailing address of the international preliminary examining authority:  <b>European Patent Office</b> <b>D-80298 Munich</b> Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465		Authorized officer  <b>Jacques, P</b>  Telephone No. +49 89 2399 8934	



**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**

International application No. PCT/GB00/00807

**I. Basis of the report**

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

**Description, pages:**

1,4-12	as originally filed			
2,3,3a	as received on	20/03/2001	with letter of	16/03/2001

**Claims, No.:**

8-15	as originally filed			
1-7	as received on	20/03/2001	with letter of	16/03/2001

**Drawings, sheets:**

1/4-4/4	as originally filed
---------	---------------------

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is: .

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**

International application No. PCT/GB00/00807

4. The amendments have resulted in the cancellation of:

- ☐ the description,      pages:
- ☐ the claims,      Nos.:
- ☐ the drawings,      sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

*(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)*

6. Additional observations, if necessary:

**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Yes: Claims 1-15
	No: Claims
Inventive step (IS)	Yes: Claims 1-15
	No: Claims
Industrial applicability (IA)	Yes: Claims 1-15
	No: Claims

2. Citations and explanations  
**see separate sheet**

**VI. Certain documents cited**

1. Certain published documents (Rule 70.10)

and / or

2. Non-written disclosures (Rule 70.9)

**see separate sheet**

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT - SEPARATE SHEET**

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International application No. PCT/GB00/00807

**Re Item V**

**Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Reference is made to the following documents:

- D1: LACKNER ET AL.: 'MULTIPLEX DNA-UND RNA-ANALYSE AN FLUORESZENTEN MICROBEADS ALS ALTERNATIVE ZUM DNA-ARRAY' MEDIZINISCHE GENETIK, vol. 11, March 1999 (1999-03), pages 16-17,  
D2: SCHENA M ET AL: 'QUANTITATIVE MONITORING OF GENE EXPRESSION PATTERNS WITH A COMPLEMENTARY DNA MICROARRAY' SCIENCE, vol. 270, no. 5235, 20 October 1995 (1995-10-20), pages 467-470,  
D3: WO 98 26098 A (FELDHAUS MICHAEL JOHN ;KAMB ALEXANDER (US); VENTANA GENETICS INC ( ) 18 June 1998 (1998-06-18),  
D4: WO 97 14028 A (LUMINEX CORP ;CHANDLER VAN S (US); FULTON R JERROLD (US); CHANDLER) 17 April 1997 (1997-04-17).

2. As amended claims 1-7 filed on 20.03.2001 do not contain subject-matter which extends beyond the content of the application as originally filed; they can be considered to meet the requirements of Articles 19(2), 34(2)(b)PCT.
3. As the particular combination of features of independent claim 1 is not disclosed in any cited prior art, the subject-matter of the said claim would appear to be novel (Article 33(2) PCT).
4. Moreover, the subject-matter of the said claim would appear to involve an inventive step in the sense of Article 33(3) PCT for the following reasons:  
The closest state of the art result from document D3.  
The said document discloses a method for comparative assessment of the level of specific nucleic acid sequences in samples from different sources (Abstract).  
The said method comprises providing the target nucleic acids from the first source linked to a first label and the target nucleic acids from the second source linked to a second label. The labelled nucleic acids from the different sources are pooled

and contacted with a number of beads each having attached thereto capture oligonucleotides of a unique sequence, under condition that promote the formation of duplexes between the capture probe and the nucleic acid molecules complements. The beads are then sorted according to the relative amount of the first label and the second label. The identity of the nucleic acid molecules is then determined (see page 12, lines 11 to 20). The method disclosed in D3 is thus a way of identifying the sequence of differentially expressed genes.

The subject-matter of claim 1 is distinguished therefrom by the following two features:

- the beads of one reagent is distinguishable from the beads of another reagent,
- the said beads are analyzed by flow cytometry.

The technical effect of these distinguishing features results in the simultaneously determination of the identity of each bead analyzed, thus determining the identity of the target nucleic acids bound on it, and the quantification of the amount of the said known target nucleic acids, bound to the said bead.

The technical problem to be solved by the invention was therefore to provide a method allowing the determination of the level of expression of specific nucleic acids from two samples.

Document D4 discloses a method for monitoring expression based on the use of subsets of beads, each subset having attached thereto capture oligonucleotides of a unique sequence, and being distinguishable from the other subset of beads by flow cytometry, thus allowing simultaneous determination of the identity of the subset of beads and quantification of the amount of nucleic acids bound (see page 9, line 4 to page 10, line 24).

However, document D4 does not disclose that the above mentioned beads can be used to determine the level of expression of nucleic acids from two different samples. D4 does not disclose that the two nucleic acids from the two samples are labelled with two different markers, thus allowing to determine the ratio of the two analytes bound to one subset of beads.

Thus, as the solution to the above mentioned problem is not disclosed nor suggested in D3 when taken alone or in combination with the other cited documents, the subject-matter of claim 1 involves an inventive step in the sense

of Article 33(3) PCT.

The same applies to dependent claims 2 to 15.

5. Additional note:

it would appear that :

- if the claimed priority date (12.03.99) is not valid or
  - if the said date is valid but if the publication date of D1 (March 99) is prior to the said date,
- document D1 would be relevant and the following would apply:

The closest prior art would result from document D1.

The said document discloses "suspension arrays" which are an alternative to DNA-arrays used in methods for monitoring expression (see abstract).

The method for monitoring expression disclosed in D1 consist of providing amplimers which are labelled with different fluorescent labels (page 17, lines 5-9).

The said amplimers are mixed to a population of microbeads which are labelled with different fluorescent markers attached to the beads (distinguishable beads) (page 16, right column, second paragraph, lines 5-7). The said beads carrying a population of oligonucleotides, wherein each population of beads carries one specific oligonucleotide (page 17, left column, lines). After hybridization, the beads are analysed by flow cytometry (Abstract and page 17, left column, line 13-24).

The subject-matter of claim 1 is distinguished therefrom by the following feature:  
nucleic acids from two sources are provided.

The technical effect of this distinguishing feature results in comparing the relative expression of each nucleic acid.

The technical problem to be solved by the invention was therefore to provide a method for comparative assessment of the level of specific nucleic acid sequences from different sources.

The person skilled in the art would turn to document D2 for the solution of this particular problem.

Document D2 discloses quantitative monitoring of gene expression patterns with a complementary DNA micro-array wherein differential gene expression of two

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT - SEPARATE SHEET**

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International application No. PCT/GB00/00807

mRNA from two sources is compared. The said mRNA, labelled with two different fluorescent labels, are mixed and hybridized to a single array. The level of expression of each mRNA is then measured by carrying out a fluorescent-specific scan (measuring the intensity of fluorescence of each label) of the same array (see page 468, column 2, line 10 to column 3, line 27).

Thus, the skilled person would have adapted the solution disclosed in D2 (hybridizing two nucleic acids to the same single array) to microbeads to solve the above mentioned problem without the exercise of any inventive skill.

Therefore, if document D1 would appear to be relevant, the subject-matter of claim 1 would not meet the requirements of Article 33(3) PCT.

**Re Item VI**

**Certain documents cited**

1. The priority documents of the present application were not available at the time that this report was written. Consequently, the documents cited as P'Y' in the I.S.R. may become pertinent to some or all of the claims at a later stage of the procedure.

## PATENT COOPERATION TREATY

## PCT

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference <b>PA9902</b>	<b>FOR FURTHER ACTION</b> see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. <b>PCT/GB 00/ 00807</b>	International filing date (day/month/year) <b>09/03/2000</b>	(Earliest) Priority Date (day/month/year) <b>12/03/1999</b>
Applicant <b>AMERSHAM PHARMACIA BIOTECH UK LTD. et al.</b>		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

## 1. Basis of the report

- a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

☐ as suggested by the applicant.

☐ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

☒ None of the figures.

PCT/GB 00/00807

## IPC 7 C12Q1/68

### B. FIELDS SEARCHED

IPC 7 C12Q

EPO-Internal, WPI Data, PAJ, MEDLINE, BIOSIS, EMBASE, CHEM ABS Data

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	LACKNER ET AL.: "MULTIPLEX DNA-UND RNA-ANALYSE AN FLUORESZENTEN MICROBEADS ALS ALTERNATIVE ZUM DNA-ARRAY" MEDIZINISCHE GENETIK, vol. 11, March 1999 (1999-03), pages 16-17, XP000930079 the whole document	1-15
X	WO 98 26098 A (FELDHAUS MICHAEL JOHN ;KAMB ALEXANDER (US); VENTANA GENETICS INC ( ) 18 June 1998 (1998-06-18) the whole document	1-15
X	WO 97 14028 A (LUMINEX CORP ;CHANDLER VAN S (US); FULTON R JERROLD (US); CHANDLER) 17 April 1997 (1997-04-17) the whole document	1-15

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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

\*& document member of the same patent family

18 August 2000

30/08/2000

Name and mailing address of the ISA  
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Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
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Hagenmaier, S

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	<p>DATABASE ONLINE 'Online! LUMINEX CORP/NEWS RELEASE, October 1998 (1998-10) "LUMINEX AWARDED GRANT TO DEVELOP DNA TECHNOLOGY" XP002145219 abstract</p> <p>---</p>	1-15
Y	<p>WO 96 12014 A (LYNX THERAPEUTICS INC) 25 April 1996 (1996-04-25) the whole document</p> <p>---</p>	1-15
Y	<p>SCHEMA M ET AL: "QUANTITATIVE MONITORING OF GENE EXPRESSION PATTERNS WITH A COMPLEMENTARY DNA MICROARRAY" SCIENCE, vol. 270, no. 5235, 20 October 1995 (1995-10-20), pages 467-470, XP000644675 ISSN: 0036-8075</p> <p>---</p>	1-15
A	<p>VAN NESS J ET AL: "A VERSATILE SOLID SUPPORT SYSTEM FOR OLIGODEOXYNUCLEOTIDE PROBE -BASED HYBRIDIZATION ASSAYS" NUCLEIC ACIDS RESEARCH, vol. 19, no. 12, 25 June 1991 (1991-06-25), pages 3345-3350, XP000208399 ISSN: 0305-1048 the whole document</p> <p>---</p>	
P,Y	<p>WO 99 35293 A (BRENNER SYDNEY ;LYNX THERAPEUTICS INC (US); ALBRECHT GLEN (US); DU) 15 July 1999 (1999-07-15)</p> <p>---</p>	1-15
P,Y	<p>WO 99 19515 A (LUMINEX CORP) 22 April 1999 (1999-04-22) the whole document</p> <p>---</p>	1-15
P,Y	<p>WO 99 64867 A (AMERSHAM PHARM BIOTECH UK LTD ;THOMAS NICHOLAS (GB)) 16 December 1999 (1999-12-16) the whole document</p> <p>-----</p>	1-15

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 00/00807

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 9826098	A	18-06-1998	US 6060240 A	09-05-2000
			AU 5605798 A	03-07-1998
			EP 0948649 A	13-10-1999
WO 9714028	A	17-04-1997	US 5981180 A	09-11-1999
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			US 6057107 A	02-05-2000
WO 9612014	A	25-04-1996	US 5604097 A	18-02-1997
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			AU 712929 B	18-11-1999
			AU 4277896 A	06-05-1996
			AU 5266399 A	09-12-1999
			CA 2202167 A	25-04-1996
			CZ 9700866 A	17-09-1997
			DE 69513997 D	20-01-2000
			DE 69513997 T	27-07-2000
			EP 0786014 A	30-07-1997
			EP 0793718 A	10-09-1997
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			FI 971473 A	04-06-1997
			HU 77916 A	28-10-1998
			JP 10507357 T	21-07-1998
			NO 971644 A	02-06-1997
			WO 9612039 A	25-04-1996
			US 5695934 A	09-12-1997
			US 5635400 A	03-06-1997
			US 5654413 A	05-08-1997
			US 5863722 A	26-01-1999
			US 5846719 A	08-12-1998
WO 9935293	A	15-07-1999	AU 2113999 A	26-07-1999
WO 9919515	A	22-04-1999	AU 1080999 A	03-05-1999
			EP 1023464 A	02-08-2000
WO 9964867	A	16-12-1999	NONE	

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 00/00807

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C12Q1/68

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C12Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, MEDLINE, BIOSIS, EMBASE, CHEM ABS Data

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	LACKNER ET AL.: "MULTIPLEX DNA-UND RNA-ANALYSE AN FLUORESZENTEN MICROBEADS ALS ALTERNATIVE ZUM DNA-ARRAY" MEDIZINISCHE GENETIK, vol. 11, March 1999 (1999-03), pages 16-17, XP000930079 the whole document	1-15
X	WO 98 26098 A (FELDHAUS MICHAEL JOHN ; KAMB ALEXANDER (US); VENTANA GENETICS INC ()) 18 June 1998 (1998-06-18) the whole document	1-15
X	WO 97 14028 A (LUMINEX CORP ; CHANDLER VAN S (US); FULTON R JERROLD (US); CHANDLER) 17 April 1997 (1997-04-17) the whole document	1-15
-/-		

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

### \* Special categories of cited documents :

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

\*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

\*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

\*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

\*A\* document member of the same patent family

Date of the actual completion of the international search

18 August 2000

Date of mailing of the international search report

30/08/2000

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# INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 00/00807

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	<p>DATABASE ONLINE 'Online! LUMINEX CORP/NEWS RELEASE, October 1998 (1998-10) "LUMINEX AWARDED GRANT TO DEVELOP DNA TECHNOLOGY" XP002145219 abstract</p>	1-15
Y	<p>WO 96 12014 A (LYNX THERAPEUTICS INC) 25 April 1996 (1996-04-25) the whole document</p>	1-15
Y	<p>SCHEMA M ET AL: "QUANTITATIVE MONITORING OF GENE EXPRESSION PATTERNS WITH A COMPLEMENTARY DNA MICROARRAY" SCIENCE, vol. 270, no. 5235, 20 October 1995 (1995-10-20), pages 467-470, XP000644675 ISSN: 0036-8075</p>	1-15
A	<p>VAN NESS J ET AL: "A VERSATILE SOLID SUPPORT SYSTEM FOR OLIGODEOXYNUCLEOTIDE PROBE -BASED HYBRIDIZATION ASSAYS" NUCLEIC ACIDS RESEARCH, vol. 19, no. 12, 25 June 1991 (1991-06-25), pages 3345-3350, XP000208399 ISSN: 0305-1048 the whole document</p>	
P,Y	<p>WO 99 35293 A (BRENNER SYDNEY ;LYNX THERAPEUTICS INC (US); ALBRECHT GLEN (US); DU) 15 July 1999 (1999-07-15)</p>	1-15
P,Y	<p>WO 99 19515 A (LUMINEX CORP) 22 April 1999 (1999-04-22) the whole document</p>	1-15
P,Y	<p>WO 99 64867 A (AMERSHAM PHARM BIOTECH UK LTD ;THOMAS NICHOLAS (GB)) 16 December 1999 (1999-12-16) the whole document</p>	1-15

# INTERNATIONAL SEARCH REPORT

Information on patent family members

Initial International Application No  
PCT/GB 00/00807

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9826098 A	18-06-1998	US 6060240 A	09-05-2000
		AU 5605798 A	03-07-1998
		EP 0948649 A	13-10-1999
WO 9714028 A	17-04-1997	US 5981180 A	09-11-1999
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		EP 1023464 A	02-08-2000
WO 9964867 A	16-12-1999	NONE	

(19) RÉPUBLIQUE FRANÇAISE  
INSTITUT NATIONAL  
DE LA PROPRIÉTÉ INDUSTRIELLE  
PARIS

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commandes de reproduction

(21) N° d'enregistrement national : **89 09176**

(51) Int Cl<sup>6</sup> : H 04 R 1/02; H 04 N 5/64.

(12) **DEMANDE DE BREVET D'INVENTION** A1

(22) Date de dépôt : 7 juillet 1989.

(30) Priorité :

(43) Date de la mise à disposition du public de la  
demande : BOPI « Brevets » n° 2 du 11 janvier 1991.

(60) Références à d'autres documents nationaux appa-  
rentés :

(71) Demandeur(s) : Société dite : THOMSON CONSUMER  
ELECTRONICS. — FR.

(72) Inventeur(s) : Erich Spitz et Francois Micheron Thom-  
son-CSF, SCPI.

(73) Titulaire(s) :

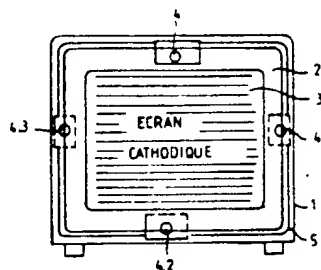
(74) Mandataire(s) : René Lardic, Thomson-CSF, SCPI.

(54) Ecran de visualisation à fonction électroacoustique intégrée.

(57) L'invention concerne un écran de visualisation 2 dont la  
surface est actionnée par un ou plusieurs moteurs de hauts  
parleurs 4, 4.1, 4.2, 4.3

Un tel écran intègre ainsi la fonction de reproduction élec-  
troacoustique.

Applications : récepteur TV à vision directe ainsi que télévi-  
sion par projection ou par rétroprojection.



FR 2 649 575 - A1

## ECRAN DE VISUALISATION A FONCTION ELECTROACOUSTIQUE INTEGREE

L'invention concerne un écran de visualisation à fonction électroacoustique intégrée.

Dans les téléviseurs, la surface frontale du coffret offre peu de possibilité d'y loger des hauts parleurs de qualité  
5 suffisante pour une reproduction électroacoustique satisfaisante. Néanmoins, compte tenu du grand volume du coffret abritant le tube cathodique, des hauts parleurs de dimensions et de qualité modestes montés dans ce type d'enceintes acoustiques procurent une reproduction acoustique  
10 convenable au moins pour la parole. On remarquera qu'à moins que la surface frontale du téléviseur ne soit considérablement agrandie pour permettre l'installation de hauts parleurs de qualité, ou que l'on utilise des hauts parleurs extérieurs, le spectateur ne bénéficie pas de la qualité acoustique  
15 potentiellement disponible dans le signal audio. La déficience de reproduction acoustique est particulièrement sensible dans le registre grave, où, pour une pression acoustique donnée, et une excursion de la membrane d'amplitude donnée, la surface de membrane du haut parleur doit être inversement proportionnelle  
20 au carré de la fréquence. Ainsi, un haut parleur de diamètre 10 cm, assurant une reproduction convenable à 150 Hz devrait voir son diamètre porté à 30 cm, avec la même excursion, pour reproduire au même niveau la fréquence de 50 Hz. Sauf cas très particulier, un haut parleur de 30 cm de diamètre n'est jamais  
25 intégré à un téléviseur.

Le problème se pose donc de trouver une grande surface frontale disponible dans un téléviseur. La solution proposée consiste à utiliser la surface de l'écran elle-même.

C'est pourquoi l'invention concerne un écran de  
30 visualisation à fonction électroacoustique intégrée caractérisé en ce qu'il comporte des moyens de commande (4, 44, 47, 49)

permettant de lui imprimer des vibrations à des fréquences acoustiques, des moyens de suspension 48 permettant de relier l'écran à un support fixe.

Les différents objets et caractéristiques de l'invention apparaîtront plus clairement dans la description qui va suivre faite à titre d'exemple en se reportant aux figures annexées qui représentent :

- les figures 1 et 2, un exemple de réalisation de l'invention appliqué à un poste de télévision ;
- 10 - la figure 3, un exemple de réalisation de moteur de commande du dispositif des figures 1 et 2 ;
- les figures 4 et 5, un autre exemple de réalisation de l'invention appliqué à un poste de télévision ;
- la figure 6, un exemple de réalisation de l'invention appliqué à un rétroprojecteur ;
- 15 - les figures 7 et 8, un exemple de réalisation de l'invention appliqué à un système de projection sur écran ;
- la figure 9, un exemple de réalisation d'un moteur de commande à inertie ;
- 20 - les figures 10, 11 et 12, un exemple de réalisation de l'invention appliqué à un écran plat du type écran à cristal liquide, à plasma, ou à diodes électroluminescentes.

Les téléviseurs cathodiques à vision directe sont aujourd'hui les plus répandus. Compte tenu de la masse, de sa fixation au coffret et de sa sensibilité aux vibrations, le tube cathodique ne peut voir son écran actionné par un moteur de haut parleur. Selon l'invention on prévoit devant l'écran du tube cathodique un panneau transparent, ou légèrement absorbant (10 à 30 % d'absorption par exemple pour l'amélioration du contraste), actionné par un ou plusieurs

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moteurs de hauts parleurs placés à sa périphérie.

Des exemples de mise en oeuvre sont donnés, à titre non limitatif.

Les figures 1 et 2 représentent un exemple de réalisation d'un poste de télévision. La vue de face de la

figure 1 montre la vue générale du poste de télévision avec un écran 2 relié au coffret 1 du poste par un joint souple 5. Le tube cathodique 3 est visible à travers l'écran 2. Des électro-amants 4, 4.1, 4.2, 4.3 permettent de faire agir l'écran 2 en membrane de haut parleur.

Sur la figure 2 représentant en coupe le téléviseur de la figure 1 on voit l'écran 2 situé devant le tube à rayons cathodiques 3 et commandé par au moins un électro-amiant 4 (ou moteur). Un blindage 6 entoure le tube à rayons cathodiques 3 pour l'isoler des effets magnétiques des moteurs (électro-amants) tels que 4.

La figure 3 représente un moteur tel que les moteurs 4 ou 4.1, 4.2, 4.3. des figures 1 ou 2.

Les moteurs considérés sont ceux des hauts parleurs électrodynamiques conventionnels. Un champ magnétique radial est créé perpendiculairement à la surface d'une bobine mobile cylindrique, soumise aux courants engendrés par le signal audio, cette bobine est solidaire de l'écran transparent, et fixée en un point à sa périphérie. Les quatre bords de l'écran sont rendus solidaires du coffret par un joint souple, de type tissu en polymère (caoutchouc synthétique) gaufré ou roulé, de technologie semblable à celle des suspensions externes des hauts parleurs électrodynamiques.

L'écran 2 est réalisé de préférence en polymère transparent, de type PMMA, ou TPX, encore plus léger, et présentant à la fois des pertes mécaniques et une rigidité supérieures.

Afin de symétriser la contrainte appliquée à l'écran transparent, plusieurs moteurs de hauts parleurs peuvent être utilisés à sa périphérie ; dans tous les cas, les fréquences audio (fréquences acoustiques) reproduites par cet écran n'excéderont pas quelques centaines de Hertz. Les fréquences supérieures seront reproduites par un ou plusieurs hauts parleurs de petites dimensions.

La figure 4 représente un exemple de réalisation dans lequel l'écran 2 possède des rebords ou des prolongements 20, 21 qui sont rabattus à 90° par rapport à la surface de l'écran. Sur ces prolongements 20, 21 sont réalisés des conducteurs 49, 49' qui font le tour de l'écran. Les prolongements 20, 21 sont situés entre des aimants 44, 44'.

Les moteurs considérés sont dérivés de ceux des hauts parleurs à ruban. Le ou les conducteurs 49, 49' soumis au courant audio sont déposés directement, par évaporation, procédé électrochimique ou autre, sur l'écran transparent, et à sa périphérie.

Ainsi, les conducteurs sont soumis à un champ magnétique tel qu'un courant circulant dans ces conducteurs entraîne un déplacement de l'écran 2 perpendiculairement à son plan. Le moteur a une longueur inférieure ou égale à la longueur du bord de l'écran qu'il anime. Quatre moteurs de ce type (un par côté de l'écran) par exemple, peuvent être mis en oeuvre pour actionner les quatre bords de l'écran ; dans ce cas, les conducteurs peuvent être continus d'un moteur à l'autre. On obtient alors un agencement tel que représenté en figure 5.

Les moteurs de hauts parleurs utilisés seront à faibles fuites magnétiques et/ou le tube cathodique sera blindé magnétiquement.

En se reportant aux figures 6 à 8, on va maintenant décrire un exemple de réalisation de l'invention appliqué à des téléviseurs à projection de l'image.

Dans ce type de téléviseurs, c'est réellement l'écran de visualisation, sur lequel s'effectue la projection, qui constitue le diaphragme du haut parleur, et non pas un écran transparent placé devant l'écran cathodique fixe du tube à vision directe.

La figure 6 représente l'application de l'invention à un appareil à rétroprojection.

La source d'images trichromes 7 est habituellement constituée de trois tubes cathodiques, rouge, vert, bleu, ou de

trois valves à cristaux liquides, munis respectivement de filtres, rouge, vert, bleu et éclairés par une même source lumineuse. Tous les modes de projection d'images sont inclus dans le dispositif représenté en figure 6 (balayage et modulation de faisceaux lasers ...). Des structures compactes de rétroprojecteurs sont obtenues par repliements des faisceaux lumineux à l'aide d'un ou plusieurs miroirs 8, 8' (voir figure 6).

L'écran de visualisation (2) reçoit les faisceaux lumineux de l'arrière et le diffuse à l'avant dans un champ angulaire délimité (écran directif ou écran à gain).

Cet écran est constitué de une ou deux feuilles de polymère transparent moulées, et porte en général sur sa face avant un réseau de lentilles semi cylindriques verticales et à l'arrière une lentille de Fresnel.

Selon l'invention les techniques utilisées pour donner à cet écran la fonction de diaphragme électroacoustique sont les mêmes que précédemment. L'écran 2 est commandé par des moteurs 4, 4' commandés par un signal audio. L'écran 2 fait alors office de membrane de haut parleur.

On notera que les excursions de l'écran perpendiculairement à son plan sont faibles (0,1 à 0,5 mm) devant la distance de mise au point (1 mètre ou plus) ; les vibrations de l'écran n'entraînent donc pas d'effets visibles sur l'image. De plus, les contraintes sur les fuites magnétiques des moteurs des hauts parleurs et/ou de blindage du tube cathodique sont fortement diminuées dans le cas du rétroprojecteur, du fait des distances moteurs-tubes.

Enfin, il est avantageux de traiter le coffret du rétroprojecteur comme une enceinte acoustique : absorbants sur les faces internes, rigidification des parois, accord de l'enceinte, soit en mode clos, soit en mode bass reflex avec évent (orifice de décompression 10).

Les figures 7 et 8 représentent un téléviseur à projection frontale.

Dans ce cas, le projecteur de télévision 7 et l'écran 2 sont séparés. Ils sont disposés comme le sont l'écran et le projecteur de diapositives ou de cinéma. Le dispositif de l'invention ne peut s'appliquer que si l'écran 2 possède une certaine rigidité, ou est monté sur un cadre ; il n'est pas possible en effet d'actionner en diaphragme de haut parleur un écran de tissu enduit, suspendu par le bord supérieur.

Les écrans de projection en télévision frontale sont souvent rigides, et épousent des formes concaves non développables (portions de paraboloïdes). De telles formes confèrent à ces écrans des propriétés de directivité, nécessaires à ce que la luminance atteigne un niveau suffisant dans le champ angulaire de vision. Ces écrans peuvent être actionnés en diaphragmes de hauts parleurs selon les techniques suivantes. On notera que contrairement aux cas précédents, l'écran est réflecteur ; le, ou les moteurs de hauts parleurs peuvent être disposés à l'arrière de l'écran, et non nécessairement à sa périphérie, comme précédemment.

Lorsque l'écran rigide est fixe sur son cadre, comme cela est représenté en figure 7, la liaison de l'écran au cadre est effectuée à l'aide de joints souples 11, 12, 13, 14, nécessaires à l'excursion de l'écran fonctionnant en diaphragme de haut parleur. La bobine mobile d'un haut parleur 4 en technologie conventionnelle est rendue solidaire de l'écran, par exemple en son centre ; l'armature de ce moteur est fixée au cadre support. D'autres configurations sont possibles, en particulier celles où toutes les liaisons de l'écran avec son cadre sont effectuées par des moteurs de hauts parleurs. Sur la figure 6 tous les joints souples 11 à 14 sont alors remplacés par des moteurs de hauts parleurs fonctionnant en phase et où le moteur central peut être supprimé.

On notera qu'un tel haut parleur fonctionne comme une membrane non bafflée, de grande surface, et qu'il s'agit d'une des configurations préférées en reproduction électroacoustique

de très haut de gamme (incluant des hauts parleurs électrostatiques et électromagnétiques à rubans larges).

5 Lorsque l'écran rigide est suspendu à un mur, comme cela est représenté en figure 8 par son bord supérieur, à l'aide d'une suspension 10, ce sont les points de contact de l'écran avec le mur 9 qui portent les joints souples et/ou le ou les moteurs de haut parleur 4.

L'invention permet également d'utiliser des moteurs à inertie tel que représentés en figure 9.

10 Les moteurs à inertie peuvent être fixés directement sur la face arrière de l'écran 2, sans points d'appui. Ils fonctionnent sur le principe "action de l'équipage mobile 50, 51, réaction de l'écran support", par égalité des quantités de mouvement :  $m \bar{V} = - M \bar{V}$ , m est la masse de l'équipage mobile  
15 (actionné par le courant audio) et v sa vitesse, M masse de l'écran et V sa vitesse. Ces moteurs sont très efficaces aux fréquences inférieures à quelques centaines de Hz, où ils excitent les modes de résonance de coque ou de plaque de l'écran ; ceux-ci seront amortis par les techniques usuelles  
20 (masses inertielles placées aux centres de vibration, joints avec le support de l'écran réalisés en matériaux souples et absorbants ....).

Enfin, l'invention est également applicable à des écrans plats que ceux-ci fonctionnent en émission lumineuse  
25 (cristaux liquides transilluminés, plasma, électroluminescence ....) ou en réflexion (cristaux liquides en réflexion, électrochromes ...).

La figure 10 représente un dispositif comportant un écran transparent 2 actionné par des moteurs de hauts parleurs périphériques, comme en figure 1, et placé devant un écran plat  
30 30.

La figure 11 représente un dispositif dans lequel l'écran plat 30 peut être actionné par ou ou plusieurs moteurs de hauts parleurs 4 solidaires d'un cadre 32, ou en appui à un mur et relié à ce cadre par des joints souples 31.

La figure 12 représente un dispositif dans lequel l'écran plat 30 est actionné par un ou plusieurs moteurs à inertie 4 qui lui sont solidaires.

5 Il est bien évident que la description qui précède a été faite qu'à titre d'exemple non limitatif et que d'autres variantes peuvent être envisagées sans sortir du cadre de l'invention.

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## REVENDICATIONS

1. Ecran de visualisation à fonction électroacoustique  
intégrée caractérisé en ce qu'il comporte des moyens de  
commande (4, 44, 47, 49) permettant de lui imprimer des  
vibrations à des fréquences acoustiques, des moyens de  
5 suspension 48 permettant de relier l'écran à un support fixe.

2. Ecran selon la revendication 1, caractérisé en ce  
qu'il comporte au moins un électro-aimant recevant un signal  
électrique à des fréquences acoustiques et possédant une  
armature mobile solidaire de l'écran.

10 3. Ecran selon la revendication 1 caractérisé en ce  
qu'il est en matériau transparent ou quasi-transparent, et qu'il  
est placé devant le tube à rayons cathodiques d'un poste de  
télévision, les moyens de commande étant placés à la périphérie  
de l'écran.

15 4. Ecran selon la revendication 3, caractérisé en ce  
qu'il comporte des moyens de blindage magnétique (6) entourant  
le tube à rayons cathodiques isolant celui-ci des  
électro-aimants.

20 5. Ecran selon la revendication 2, caractérisé en ce  
qu'il comporte au moins un aimant permanent fixe (44) et que  
l'armature mobile porte un bobinage susceptible d'être parcouru  
par un courant de commande à des fréquences acoustiques.

25 6. Ecran selon la revendication 5, caractérisé en ce  
que l'armature mobile est un prolongement (20, 21) de l'écran 2  
replié sensiblement à 90° par rapport au plan de l'écran et que  
ce prolongement (20, 21) porte des fils électriques constituant  
un bobinage susceptible d'être parcouru par un courant  
électrique à fréquence acoustique.

30 7. Ecran selon la revendication 6, caractérisé en ce  
que les quatre bords de l'écran (2) sont repliés à 90° et que  
les prolongements repliés sont situés entre des aimants.

8. Ecran selon la revendication 1, caractérisé en ce que l'écran est un écran de projection couplé à un support par un ou plusieurs transducteurs électroacoustiques.

5 9. Ecran selon la revendication 1, caractérisé en ce que l'écran est un écran plat de visualisation du type à cristaux liquide, à plasma ou à diodes électroluminescentes.

10 10. Ecran selon la revendication 1, caractérisé en ce que l'écran est l'écran d'un rétroprojecteur comportant des moyens de commande permettant d'imprimer à l'écran des vibrations à des fréquences acoustiques l'enceinte du rétroprojecteur constituant la cavité acoustique accordée. couplée à l'écran qui constitue ainsi la membrane acoustique de haut parleur.

15 11. Ecran selon la revendication 1, caractérisé en ce que les moyens de commande sont des moteurs à inertie solidaires de l'écran, l'écran pouvant être un écran de projection, de rétroprojection ou un écran plat de visualisation.

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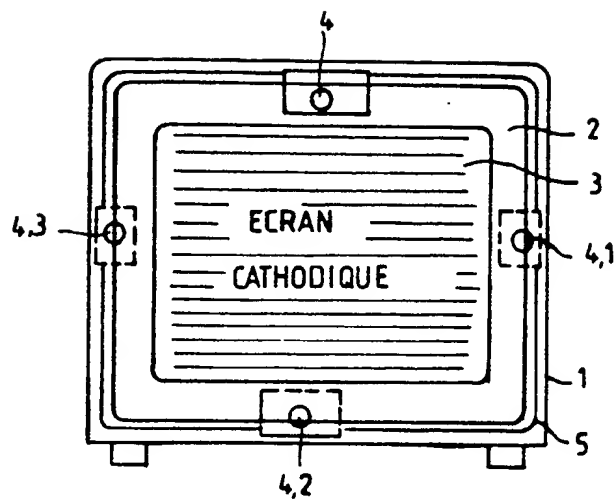


FIG. 1

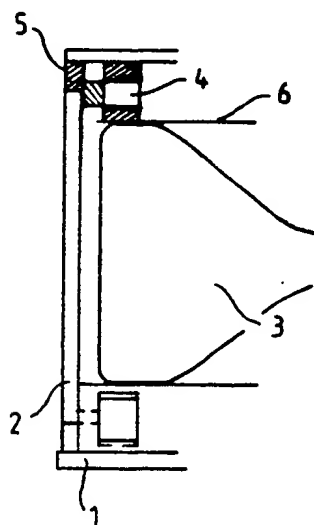


FIG. 2

2/5

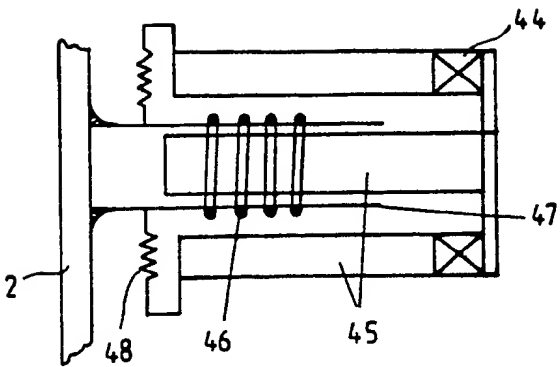


FIG. 3

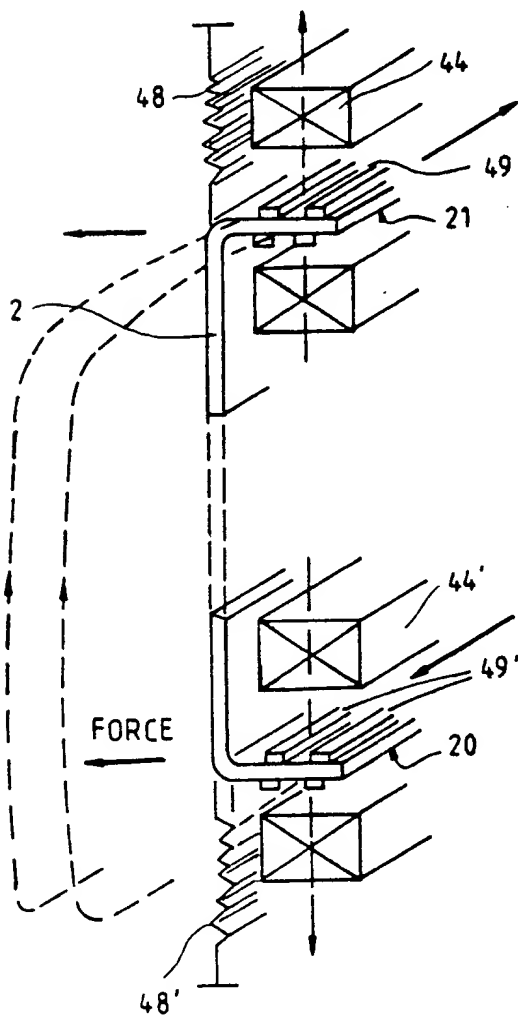


FIG. 4

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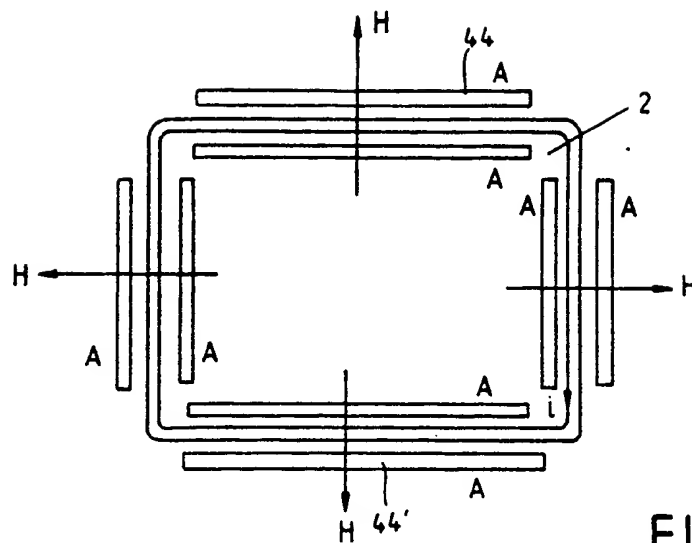


FIG. 5

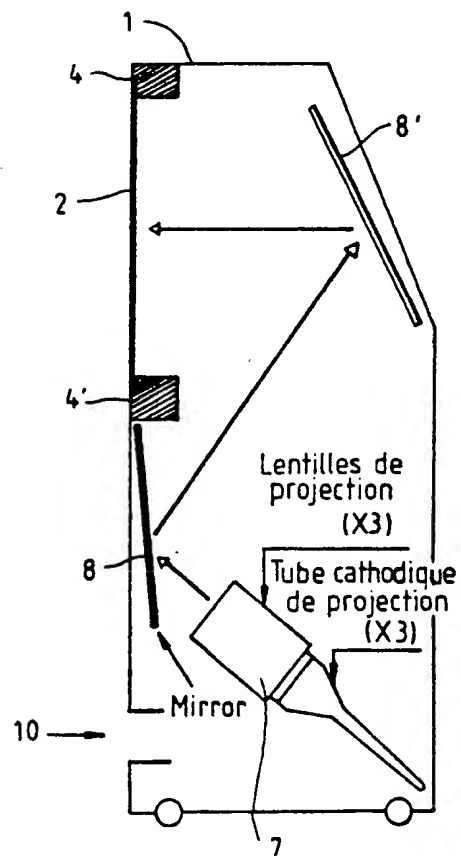


FIG. 6

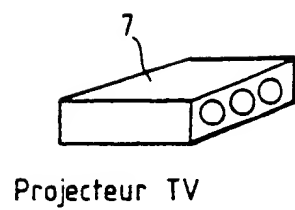


FIG. 7

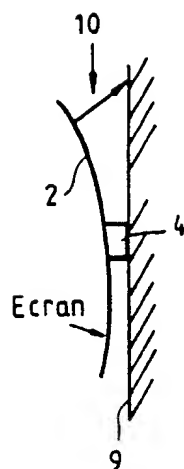
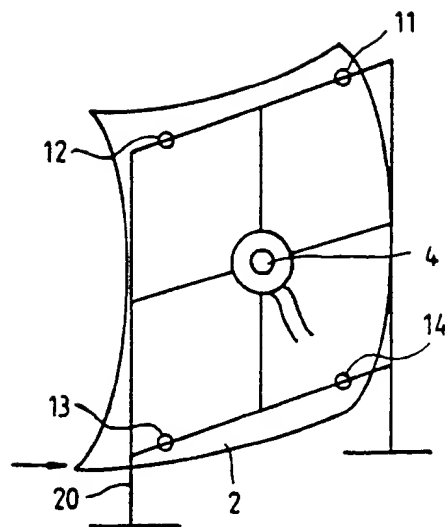


FIG. 8

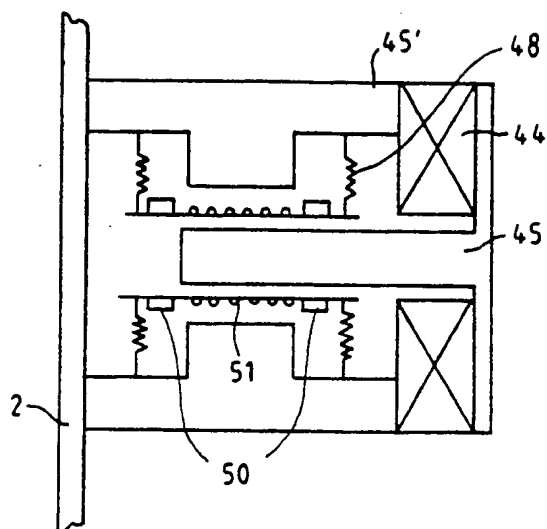


FIG. 9

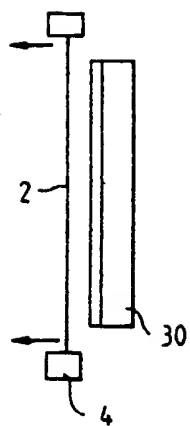


FIG. 10

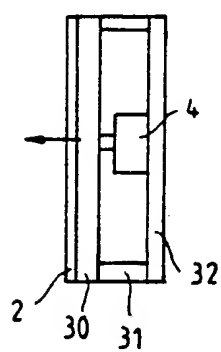


FIG. 11

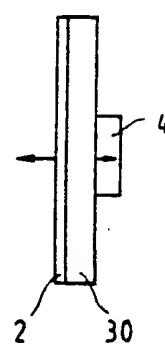


FIG. 12

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<p>(54) Title: LOUDSPEAKERS COMPRISING PANEL-FORM ACOUSTIC RADIATING ELEMENTS</p>		
<p>The diagram shows a rectangular panel-form loudspeaker (81). Inside the panel is a rectangular resonant distributed mode acoustic radiator (2). A drive means (9) is mounted to the radiator. The radiator is surrounded by a baffle (6, 8) and supported by the radiator. The diagram is labeled with 6, 2, 9, 3, 81, and 82.</p>		
<p>(57) Abstract</p> <p>A panel-form loudspeaker (81) comprising a resonant distributed mode acoustic radiator (2), and drive means (9) mounted to the radiator to excite multi-mode resonance in the radiator, characterised by a baffle (6, 8) surrounding and supporting the radiator.</p>		

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TITLE:**LOUDSPEAKERS COMPRISING PANEL-FORM ACOUSTIC RADIATING ELEMENTS**

10

DESCRIPTION

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TECHNICAL FIELD

The invention relates to loudspeakers and more particularly to loudspeakers comprising panel-form acoustic radiating elements.

BACKGROUND ART

20 It is known from GB-A-2262861 to suggest a panel-form loudspeaker comprising:-

a resonant multi-mode radiator element being a unitary sandwich panel formed of two skins of material with a spacing core of transverse cellular construction, wherein  
25 the panel is such as to have ratio of bending stiffness (B), in all orientations, to the cube power of panel mass per unit surface area ( $\mu$ ) of at least 10;

a mounting means which supports the panel or attaches

to it a supporting body, in a free undamped manner;

and an electro-mechanical drive means coupled to the panel which serves to excite a multi-modal resonance in the radiator panel in response to an electrical input within a  
5 working frequency band for the loudspeaker.

#### DISCLOSURE OF INVENTION

Embodiments of the present invention use members of nature, structure and configuration achievable generally and/or specifically by implementing teachings of our co-  
10 pending PCT application no. (our case P.5711) of even date herewith. Such members thus have capability to sustain and propagate input vibrational energy by bending waves in operative area(s) extending transversely of thickness often but not necessarily to edges of the member(s); are  
15 configured with or without anisotropy of bending stiffness to have resonant mode vibration components distributed over said area(s) beneficially for acoustic coupling with ambient air; and have predetermined preferential locations or sites within said area for transducer means,  
20 particularly operationally active or moving part(s) thereof effective in relation to acoustic vibrational activity in said area(s) and signals, usually electrical, corresponding to acoustic content of such vibrational activity. Uses are envisaged in co-pending International application No. (our  
25 file P.5711) of even date herewith for such members as or in "passive" acoustic devices without transducer means, such as for reverberation or for acoustic filtering or for acoustically "voicing" a space or room; and as or in

"active" acoustic devices with transducer means, such as in a remarkably wide range of sources of sound or loudspeakers when supplied with input signals to be converted to said sound, or in such as microphones when exposed to sound to  
5 be converted into other signals.

This invention is particularly concerned with active acoustic devices in the form of loudspeakers. Members as above are herein called distributed mode acoustic radiators and are intended to be characterised as in the above PCT  
10 application and/or otherwise as specifically provided herein.

According to the invention a panel-form loudspeaker comprises a resonant multi-mode acoustic radiator, drive means mounted to the radiator to excite multi-mode  
15 resonance in the radiator, and a baffle surrounding and supporting the radiator. A resilient suspension may be interposed between the radiator and the surround. The resilient suspension may be of an elastomeric material such as rubber and may be sponge-like, e.g. foamed rubber.

20 The baffle may be substantially planar or may be in the form of an enclosure, e.g. a box-like enclosure. The baffle may be of any suitable rigid material, e.g. medium density fibreboard. When the baffle is formed into an enclosure it may be of so-called 'infinite baffle' form or  
25 may be ported.

The transducer may be mounted wholly and exclusively on the radiator.

The enclosure may comprise a rear box portion adapted

to be buried in a wall or the like surface and a front box portion adapted to project from the wall or the like. The radiator may comprise a lightweight core separating a pair of higher modulus lightweight skins.

- 5           A subwoofer, which may be a conventional cone driver, and/or a tweeter, which may be of known construction, may be mounted to the baffle.

#### BRIEF DESCRIPTION OF DRAWINGS

The invention is diagrammatically illustrated, by way  
10 of example, in the accompanying drawings, in which:-

Figure 1 is a diagram showing a distributed-mode member as described and claimed in our co-pending International application No... (our case P.5711) of even date herewith;

- 15           Figure 2a is a partial section on the line A-A of Figure 1;

Figure 2b is an enlarged cross-section through a distributed mode radiator of the kind shown in Figure 2a and showing two alternative constructions;

- 20           Figure 3 is a diagram of a first embodiment of distributed-mode loudspeaker according to the present invention;

Figure 4a is a perspective view of a second embodiment of distributed-mode loudspeaker according to the present  
25 invention;

Figure 4b is a partial cross-sectional view of the loudspeaker of Figure 4a;

Figure 5a is a perspective view of a third embodiment

of distributed-mode loudspeaker according to the present invention, and

Figure 5b is a partial cross-sectional view of the loudspeaker of Figure 5a.

5           BEST MODES FOR CARRYING OUT THE INVENTION

Referring to Figure 1 of the drawings, there is shown a panel-form loudspeaker (81) of the kind described and claimed in our co-pending International application No. (our case P.5711) of even date herewith comprising a  
5 rectangular frame (1) carrying a resilient suspension (3) round its inner periphery which supports a distributed mode sound radiating panel (2). A transducer (9) e.g as described in detail with reference to our co-pending International applications Nos. (our cases P.5683/4/5) of  
10 even date herewith, is mounted wholly and exclusively on or in the panel (2) at a predetermined location defined by dimensions  $x$  and  $y$ , the position of which location is calculated as described in our co-pending International application No. (our case P.5711) of even date herewith,  
15 to launch bending waves into the panel to cause the panel to resonate to radiate an acoustic output.

The transducer (9) is driven by a signal amplifier (10), e.g. an audio amplifier, connected to the transducer by conductors (28). Amplifier loading and power  
20 requirements can be entirely normal, similar to conventional cone type speakers, sensitivity being of the order of 86 - 88dB/watt under room loaded conditions. Amplifier load impedance is largely resistive at 6 ohms,

power handling 20-80 watts. Where the panel core and/or skins are of metal, they may be made to act as a heat sink for the transducer to remove heat from the motor coil of the transducer and thus improve power handling.

5        Figures 2a and 2b are partial typical cross-sections through the loudspeaker (81) of Figure 1. Figure 2a shows that the frame (1), surround (3) and panel (2) are connected together by respective adhesive-bonded joints (20). Suitable materials for the frame include lightweight  
10 framing, e.g. picture framing of extruded metal e.g. aluminium alloy or plastics. Suitable surround materials include resilient materials such as foam rubber and foam plastics. Suitable adhesives for the joints (20) include epoxy, acrylic and cyano-acrylate etc. adhesives.

15        Figure 2b illustrates, to an enlarged scale, that the panel (2) is a rigid lightweight panel having a core (22) e.g. of a rigid plastics foam (97) e.g. cross linked polyvinylchloride or a cellular matrix (98) i.e. a honeycomb matrix of metal foil, plastics or the like, with  
20 the cells extending transversely to the plane of the panel, and enclosed by opposed skins (21) e.g. of paper, card, plastics or metal foil or sheet. Where the skins are of plastics, they may be reinforced with fibres e.g. of carbon, glass, Kevlar (RTM) or the like in a manner known  
25 per se to increase their modulus.

Envisaged skin layer materials and reinforcements thus include carbon, glass, Kevlar (RTM), Nomex (RTM) i.e. aramid etc. fibres in various lays and weaves, as well as

paper, bonded paper laminates, melamine, and various synthetic plastics films of high modulus, such as Mylar (RTM), Kaptan (RTM), polycarbonate, phenolic, polyester or related plastics, and fibre reinforced plastics, etc. and metal sheet or foil. Investigation of the Vectra grade of liquid crystal polymer thermoplastics shows that they may be useful for the injection moulding of ultra thin skins or shells of smaller size, say up to around 30cm diameter. This material self forms an orientated crystal structure in the direction of injection, a preferred orientation for the good propagation of treble energy from the driving point to the panel perimeter.

Additional such moulding for this and other thermoplastics allows for the mould tooling to carry location and registration features such as grooves or rings for the accurate location of transducer parts e.g. the motor coil, and the magnet suspension. Additional with some weaker core materials it is calculated that it would be advantageous to increase the skin thickness locally e.g. in an area or annulus up to 150% of the transducer diameter, to reinforce that area and beneficially couple vibration energy into the panel. High frequency response will be improved with the softer foam materials by this means.

Envisaged core layer materials include fabricated honeycombs or corrugations of aluminium alloy sheet or foil, or Kevlar (RTM), Nomex (RTM), plain or bonded papers, and various synthetic plastics films, as well as expanded

or foamed plastics or pulp materials, even aerogel metals  
if of suitably low density. Some suitable core layer  
materials effectively exhibit usable self-skinning in their  
manufacture and/or otherwise have enough inherent stiffness  
5 for use without lamination between skin layers. A high  
performance cellular core material is known under the trade  
name 'Rohacell' which may be suitable as a radiator panel  
and which is without skins. In practical terms, the aim is  
for an overall lightness and stiffness suited to a  
10 particular purpose, specifically including optimising  
contributions from core and skin layers and transitions  
between them.

Several of the preferred formulations for the panel  
employ metal and metal alloy skins, or alternatively a  
15 carbon fibre reinforcement. Both of these, and also  
designs with an alloy Aerogel or metal honeycomb core, will  
have substantial radio frequency screening properties which  
should be important in several EMC applications.  
Conventional panel or cone type speakers have no inherent  
20 EMC screening capability.

In addition the preferred form of piezo and electro  
dynamic transducers have negligible electromagnetic  
radiation or stray magnet fields. Conventional speakers  
have a large magnetic field, up to 1 metre distant unless  
25 specific compensation counter measures are taken.

Where it is important to maintain the screening in an  
application, electrical connection can be made to the  
conductive parts of an appropriate DML panel or an

electrically conductive foam or similar interface may be used for the edge mounting.

The suspension (3) may damp the edges of the panel (2) to prevent excessive edge movement of the panel. Additionally or alternatively, further damping may be applied, e.g. as patches, bonded to the panel in selected positions to damp excessive movement to distribute resonance equally over the panel. The patches may be of bitumen-based material, as commonly used in conventional loudspeaker enclosures or may be of a resilient or rigid polymeric sheet material. Some materials, notably paper and card, and some cores may be self-damping. Where desired, the damping may be increased in the construction of the panels by employing resiliently setting, rather than rigid setting adhesives.

Effective said selective damping includes specific application to the panel including its sheet material of means permanently associated therewith. Edges and corners can be particularly significant for dominant and less dispersed low frequency vibration modes of panels hereof. Edge-wise fixing of damping means can usefully lead to a panel with its said sheet material fully framed, though their corners can often be relatively free, say for desired extension to lower frequency operation. Attachment can be by adhesive or self-adhesive materials. Other forms of useful damping, particularly in terms of more subtle effects and/or mid- and higher frequencies can be by way of suitable mass or masses affixed to the sheet material at

predetermined effective medial localised positions of said area.

An acoustic panel as described above is bi-directional. The sound energy from the back is not  
5 strongly phase related to that from the front. Consequently there is the benefit of overall summation of acoustic power in the room, sound energy of uniform frequency distribution, reduced reflective and standing wave effects and with the advantage of superior  
10 reproduction of the natural space and ambience in the reproduced sound recordings.

While the radiation from the acoustic panel is largely non-directional, the percentage of phase related information increases off axis. For improved focus for the  
15 phantom stereo image, placement of the speakers, like pictures, at the usual standing person height, confers the benefit of a moderate off-axis placement for the normally seated listener optimising the stereo effect. Likewise the triangular left/right geometry with respect to the listener  
20 provides a further angular component. Good stereo is thus obtainable.

There is a further advantage for a group of listeners compared with conventional speaker reproduction. The intrinsically dispersed nature of acoustic panel sound  
25 radiation gives it a sound volume which does not obey the inverse square law for distance for an equivalent point source. Because the intensity fall-off with distance is much less than predicted by inverse square law then

consequently for off-centre and poorly placed listeners the intensity field for the panel speaker promotes a superior stereo effect compared to conventional speakers. This is because the off-centre placed listener does not suffer the  
5 doubled problem due to proximity to the nearer speaker; firstly the excessive increase in loudness from the nearer speaker, and then the corresponding decrease in loudness from the further loudspeaker.

There is also the advantage of a flat, lightweight  
10 panel-form speaker, visually attractive, of good sound quality and requiring only one transducer and no crossover for a full range sound from each panel diaphragm.

Figure 3 illustrates a first embodiment of distributed mode panel-form loudspeaker (81) generally of the kind  
15 shown in Figures 1 and 2 and in which the frame (1) is replaced by a baffle-board (6), e.g. of medium density fibreboard, having a rectangular aperture (82) in which a distributed mode radiator panel (2) is mounted with the interposition of a resilient suspension (3). A transducer  
20 (9) of the kind described in our co-pending International application Nos. (our cases P.5683/4/5) of even date herewith is mounted wholly and exclusively on the panel (2) to vibrate the panel to cause it to resonate to produce an acoustic output.

25 Such a baffle may have the effect of augmenting lower frequency response of the loudspeaker.

Figure 4 illustrates a second embodiment of loudspeaker (81) according to the present invention. The

loudspeaker comprises a box-like enclosure (8) having a top (148), a bottom (149), opposed sides (150), a back (151) and a front (152). The front (152) of the enclosure (8) consists of a rigid lightweight distributed mode radiator panel (2) of the kind described with reference to Figures 1 and 2 and comprising a core (22) enclosed by opposed skins (21). The panel (2) is supported in the enclosure (8) by means of a surrounding compliant suspension (17), e.g. a strip of latex rubber. An acoustic absorbing lining may be provided in the enclosure.

A transducer (9) e.g. of the kinds shown in our co-pending International applications Nos. (our cases P.5683/4/5) of even date herewith is mounted wholly and exclusively on the inwardly directed face of the panel (2) in a predetermined location as discussed in our co-pending International application No. (our file P.5711) of even date herewith, to vibrate the panel to cause it to resonate to produce an acoustic output.

The enclosure (8) may be formed with ports (109) e.g. in one side (150), to enhance bass performance of the loudspeaker. In any event, the use of the enclosure (8) will render the loudspeaker uni-directional, which may be desirable in some circumstances.

Figure 5 illustrates a further embodiment of loudspeaker (81) according to the present invention and generally similar to that described above with reference to Figure 4. The loudspeaker comprises a box-like enclosure (8) consisting of a front box portion (52) having an open

back adapted to be mounted on a wall and aligned with a cavity (110) in the wall, e.g. in a stud-work wall, to reduce the depth of the loudspeaker enclosure while providing the benefits of a larger enclosure. The front  
5 face (51) of the front box consists of a rigid lightweight distributed mode radiator (2) comprising a core (22) enclosed by opposed skins (21). The panel (2) is supported in the enclosure (8) by means of a surrounding resilient suspension (17), e.g. of rubber latex strip. The  
10 loudspeaker is thus generally of the kind described with reference to Figures 1 and 2 above.

A transducer (9), e.g. of the kind described with reference to our co-pending International application Nos. (our cases P.5683/4/5) of even date herewith is mounted  
15 wholly and exclusively on the inwardly directed face of the panel (2) in a predetermined location as discussed in our co-pending International application No. (our ref P.5711) to vibrate the panel to cause it to resonate to produce an acoustic output.

20

#### INDUSTRIAL APPLICABILITY

The loudspeakers of the present invention are relatively simple to make and can be made to have a relatively shallow depth, or apparently shallow depth, in comparison to conventional loudspeakers. The loudspeakers  
25 of the present invention have a wide angle of dispersion in comparison to conventional pistononic loudspeakers. Where the radiator panel is made from or is skinned with metal foil or sheet, the loudspeaker can be made to be shielded

against radio-frequency emissions.

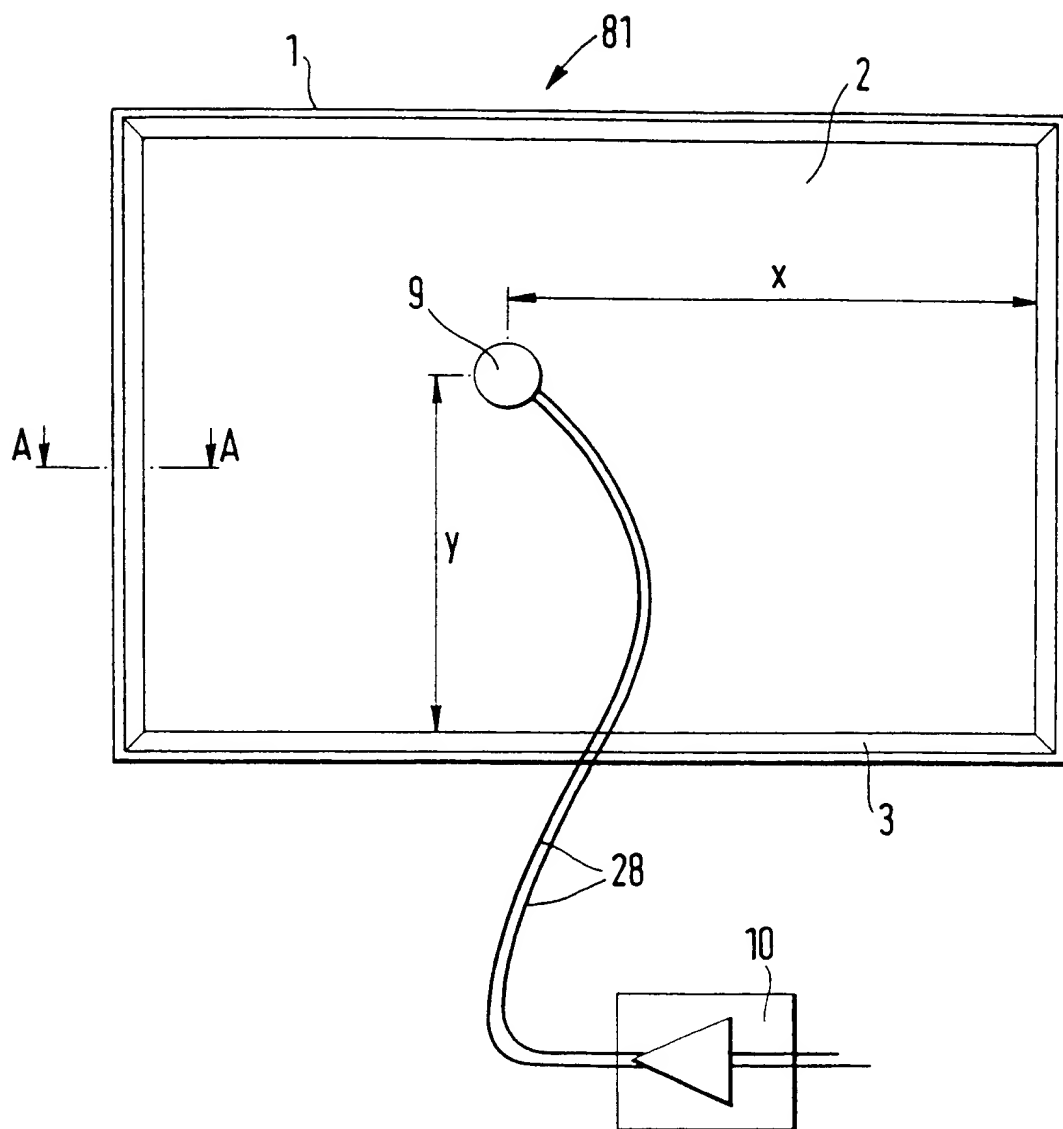
CLAIMS

1. A panel-form loudspeaker (81) comprising a resonant distributed mode acoustic radiator (2), and drive means (9) mounted to the radiator to excite distributed mode  
5 resonance in the radiator, characterised by a baffle (6,8) surrounding and supporting the radiator.
2. A panel-form loudspeaker according to claim 1, characterised by resilient suspension (3,17) between the radiator (2) and the surround (6,8) to support the radiator  
10 in the baffle.
3. A panel-form loudspeaker according to claim 1 or claim 2, characterised in that the resilient suspension (3,17) is of an elastomeric material.
4. A panel-form loudspeaker according to any one of  
15 claims 1 to 3, characterised in that the transducer (9) is mounted wholly and exclusively on the radiator (2).
5. A panel-form loudspeaker according to any preceding claim, characterised in that the baffle (8) is formed as an enclosure having an open backed front box portion (52)  
20 adapted to be mounted on a wall or the like.
6. A panel-form loudspeaker according to claim 5, characterised in that the front box portion (52) is adapted to be mounted to align with a cavity (110) in the wall.
7. A panel-form loudspeaker according to any preceding  
25 claim, characterised in that the radiator (2) comprises a lightweight core (22) separating a pair of high modulus lightweight skins (21).
8. A panel-form loudspeaker according to any preceding

claim, characterised by a subwoofer mounted to the baffle  
(6,8).

9. A panel-form loudspeaker according to any preceding  
claim, characterised by a tweeter mounted to the baffle  
5 (6,8).

1/5

*Fig. 1*

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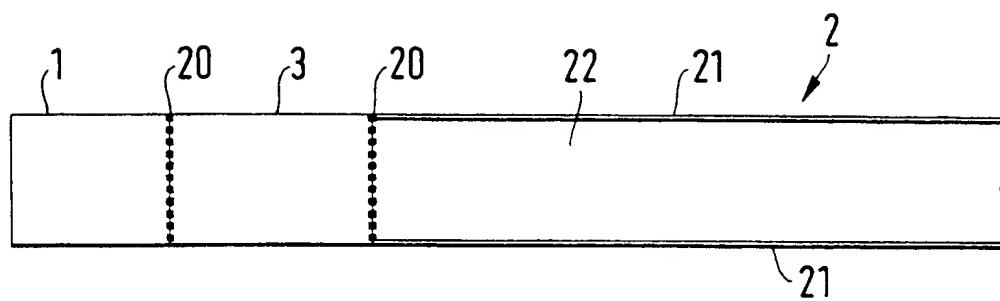


Fig. 2a

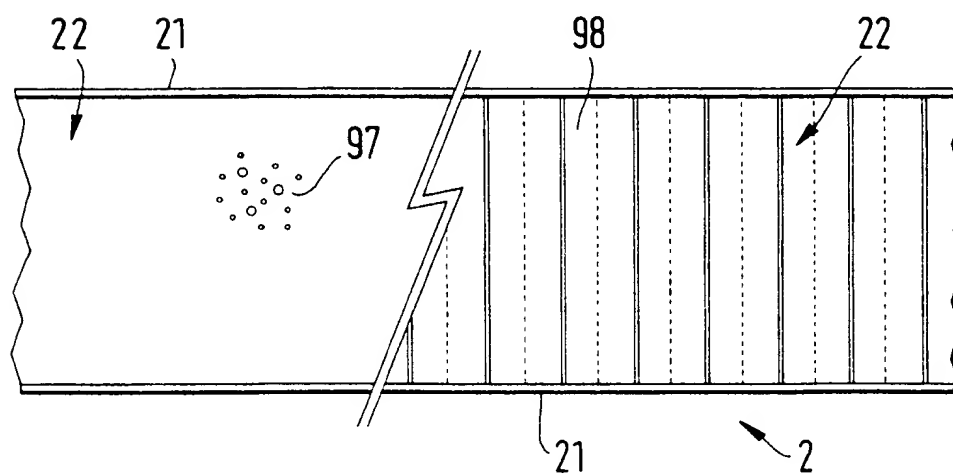


Fig. 2b

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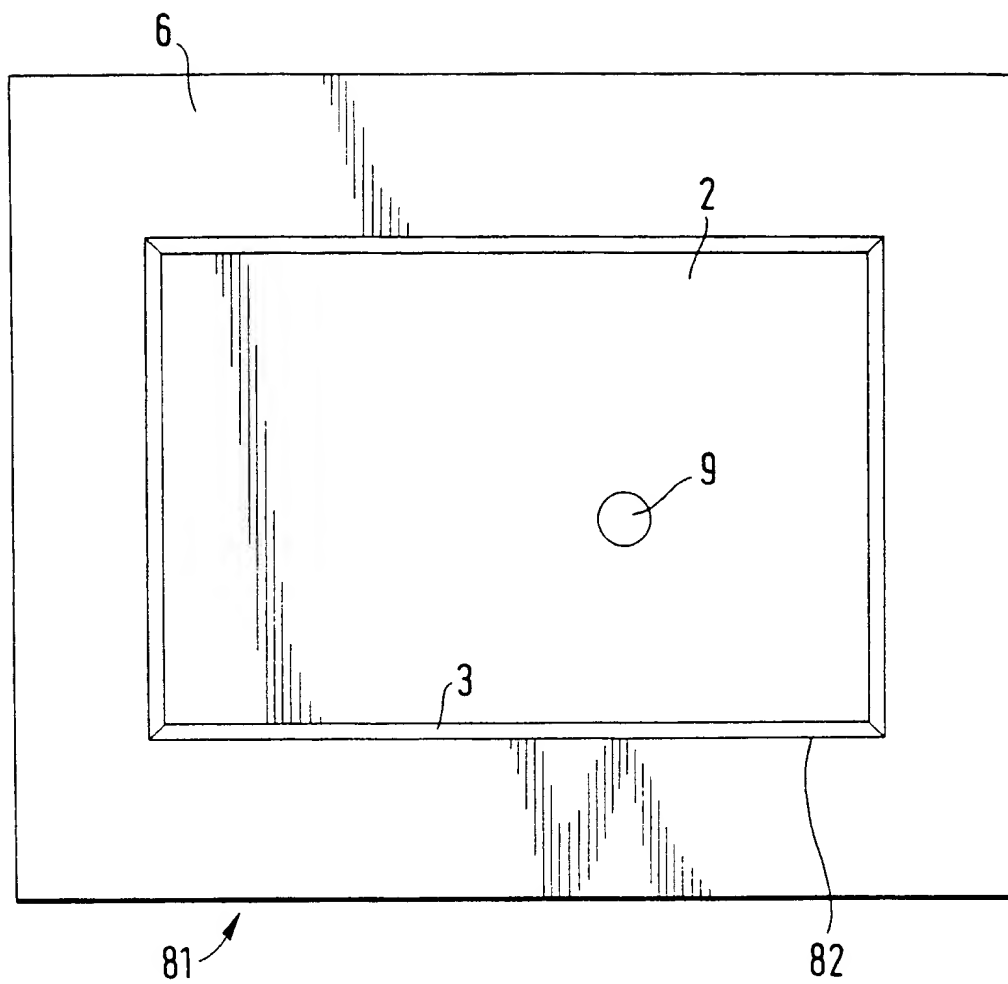


Fig. 3

4/5

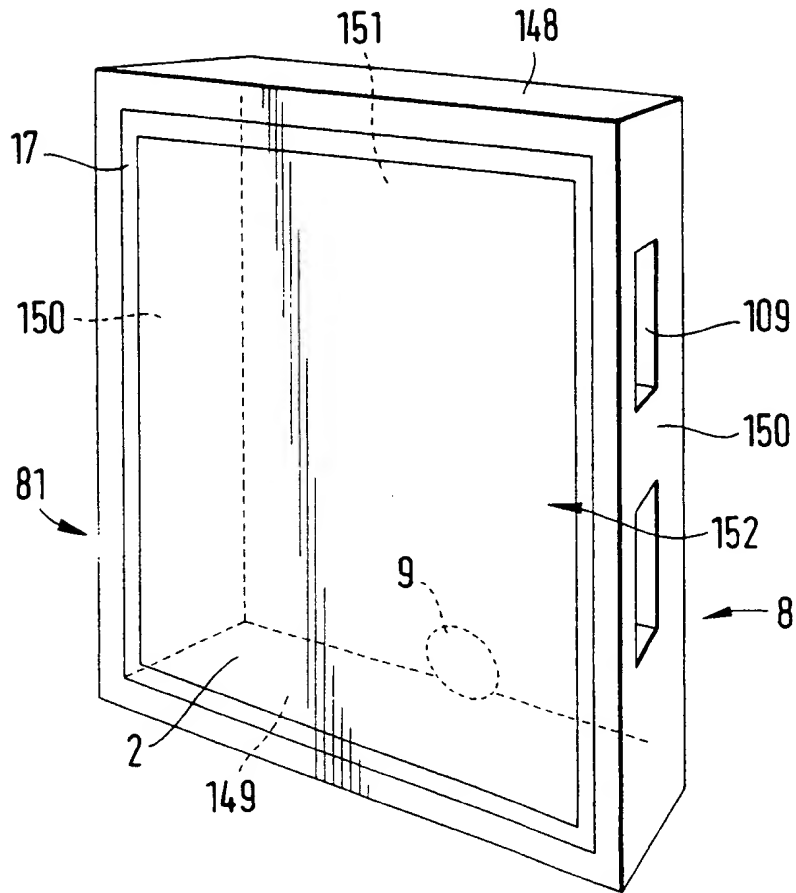


Fig. 4a

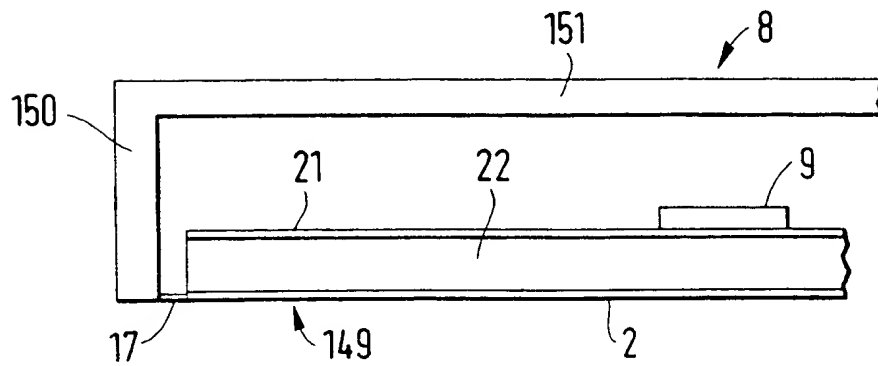


Fig. 4b

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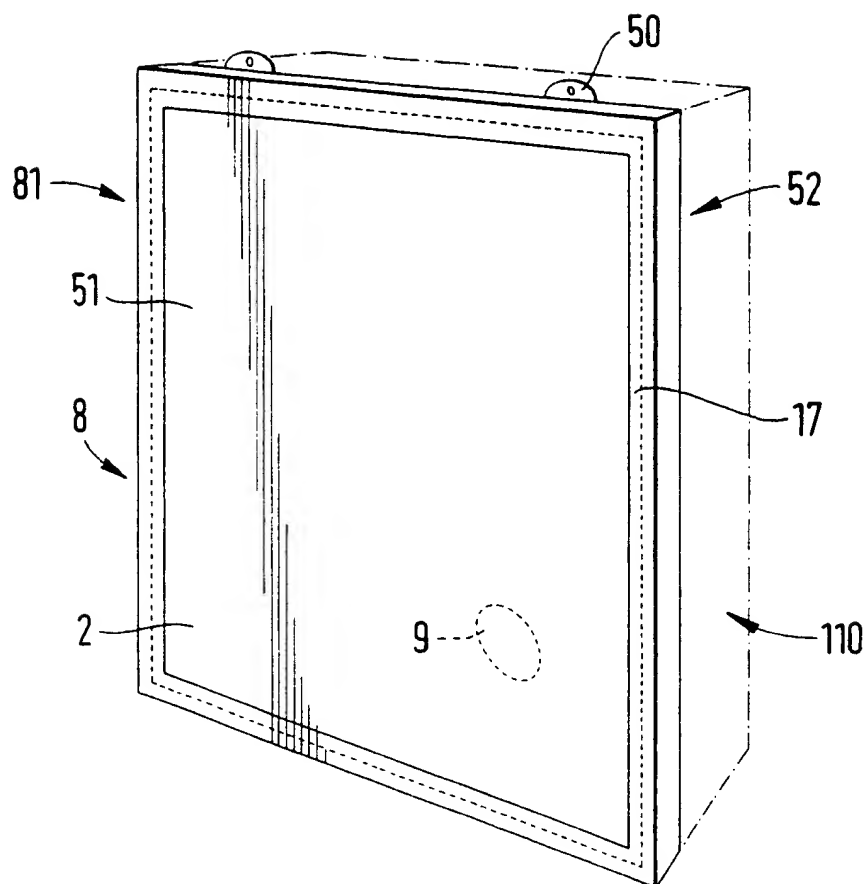


Fig. 5a

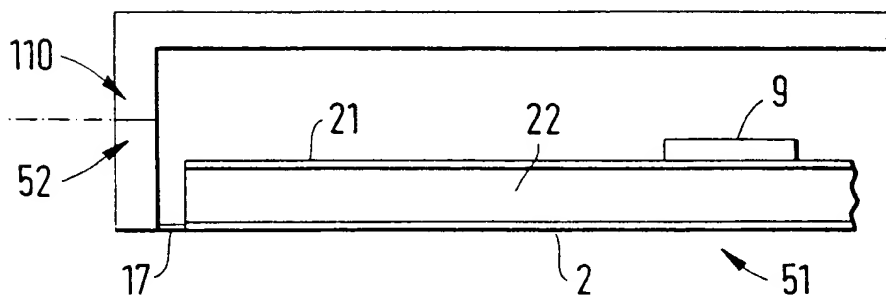


Fig. 5b

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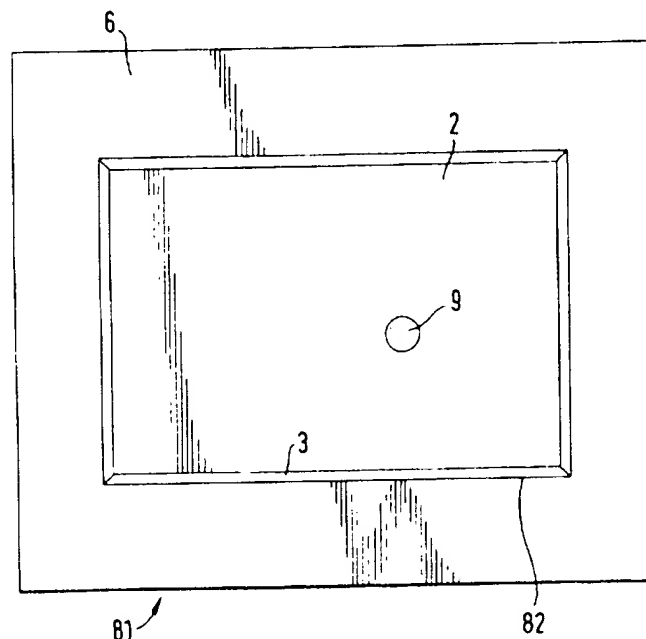
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(71) Applicant (for all designated States except US): VERITY GROUP PLC [GB/GB]; Stonehill, Huntingdon, Cambridgeshire PE18 6ED (GB).		<b>Published</b> <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>	
(72) Inventors; and (75) Inventors/Applicants (for US only): AZIMA, Henry [CA/GB]; 3 Southacre Close, Chaucer Road, Cambridge CB2 2TT (GB). COLLOMS, Martin [GB/GB]; 22 Burgess Hill, London NW2 2DA (GB). HARRIS, Neil [GB/GB]; 9 Davey Crescent, Great Shelford, Cambridge CB2 5JF (GB).		(88) Date of publication of the international search report: 03 April 1997 (03.04.97)	
(74) Agent: MAGUIRE & CO.; 5 Crown Street, St. Ives, Cambridgeshire PE17 4EB (GB).			

(54) Title: LOUDSPEAKERS COMPRISING PANEL-FORM ACOUSTIC RADIATING ELEMENTS



(57) Abstract

A panel-form loudspeaker (81) comprising a resonant distributed mode acoustic radiator (2), and drive means (9) mounted to the radiator to excite multi-mode resonance in the radiator, characterised by a baffle (6, 8) surrounding and supporting the radiator.

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# INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER  
IPC 6 H04R1/02 H04R7/06

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 H04R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 3 247 925 A (WARNAKA) 26 April 1966 see column 2, line 55 - column 3, line 38; figures ---	1,7
A	GB 2 010 637 A (SONY CORP) 27 June 1979 see page 2, line 77 - page 3, line 78; figures ---	2,3,7
A	US 5 400 407 A (CASSITY ET AL.) 21 March 1995 see column 1, line 16 - column 2, line 47; figures ---	5,6
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☒ Further documents are listed in the continuation of box C.

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
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		DE-T- 69106712	08-06-95
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<table style="width: 100%; border: none;"> <tr> <td style="width: 50%; vertical-align: top; padding: 5px;"> <p>(21) International Application Number: PCT/GB96/02153</p> <p>(22) International Filing Date: 2 September 1996 (02.09.96)</p> <p>(30) Priority Data:</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 30%;">9517918.0</td> <td style="width: 40%;">2 September 1995 (02.09.95)</td> <td style="width: 30%;">GB</td> </tr> <tr> <td>9522281.6</td> <td>31 October 1995 (31.10.95)</td> <td>GB</td> </tr> <tr> <td>9606836.6</td> <td>30 March 1996 (30.03.96)</td> <td>GB</td> </tr> </table> <p>(71) Applicant (for all designated States except US): VERITY GROUP PLC [GB/GB]; Stonehill, Huntingdon, Cambridgeshire PE18 6ED (GB).</p> <p>(72) Inventors; and</p> <p>(75) Inventors/Applicants (for US only): AZIMA, Henry [CA/GB]; 3 Southacre Close, Chaucer Road, Cambridge CB2 2TT (GB). COLLOMS, Martin [GB/GB]; 22 Burgess Hill, London NW2 2DA (GB). HARRIS, Neil [GB/GB]; 9 Davey Crescent, Great Shelford, Cambridge CB2 5JF (GB).</p> <p>(74) Agent: MAGUIRE &amp; CO.; 5 Crown Street, St. Ives, Cambridgeshire PE17 4EB (GB).</p> </td> <td style="width: 50%; vertical-align: top; padding: 5px;"> <p>(81) Designated States: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</p> <p><b>Published</b> <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p> </td> </tr> </table>			<p>(21) International Application Number: PCT/GB96/02153</p> <p>(22) International Filing Date: 2 September 1996 (02.09.96)</p> <p>(30) Priority Data:</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 30%;">9517918.0</td> <td style="width: 40%;">2 September 1995 (02.09.95)</td> <td style="width: 30%;">GB</td> </tr> <tr> <td>9522281.6</td> <td>31 October 1995 (31.10.95)</td> <td>GB</td> </tr> <tr> <td>9606836.6</td> <td>30 March 1996 (30.03.96)</td> <td>GB</td> </tr> </table> <p>(71) Applicant (for all designated States except US): VERITY GROUP PLC [GB/GB]; Stonehill, Huntingdon, Cambridgeshire PE18 6ED (GB).</p> <p>(72) Inventors; and</p> <p>(75) Inventors/Applicants (for US only): AZIMA, Henry [CA/GB]; 3 Southacre Close, Chaucer Road, Cambridge CB2 2TT (GB). COLLOMS, Martin [GB/GB]; 22 Burgess Hill, London NW2 2DA (GB). HARRIS, Neil [GB/GB]; 9 Davey Crescent, Great Shelford, Cambridge CB2 5JF (GB).</p> <p>(74) Agent: MAGUIRE &amp; CO.; 5 Crown Street, St. Ives, Cambridgeshire PE17 4EB (GB).</p>	9517918.0	2 September 1995 (02.09.95)	GB	9522281.6	31 October 1995 (31.10.95)	GB	9606836.6	30 March 1996 (30.03.96)	GB	<p>(81) Designated States: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</p> <p><b>Published</b> <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>
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<p>(54) Title: LOUDSPEAKERS COMPRISING PANEL-FORM ACOUSTIC RADIATING ELEMENTS</p> <div style="text-align: center; margin: 20px 0;"> </div>													
<p>(57) Abstract</p> <p>A ceiling tile (36) for a suspended ceiling and incorporating a loudspeaker (81) characterised in that the tile is in the form of a distributed mode acoustic radiator (2), and by a transducer (9) mounted wholly and exclusively on the radiator to vibrate the radiator to cause it to resonate.</p>													

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5

TITLE:

LOUDSPEAKERS COMPRISING PANEL-FORM ACOUSTIC RADIATING ELEMENTS

10

DESCRIPTION

15

TECHNICAL FIELD

The invention relates to loudspeakers and more particularly to loudspeakers comprising panel-form acoustic radiating elements.

BACKGROUND ART

20

It is known from GB-A-2262861 to suggest a panel-form loudspeaker comprising:-

a resonant multi-mode radiator element being a unitary sandwich panel formed of two skins of material with a spacing core of transverse cellular construction, wherein  
25 the panel is such as to have ratio of bending stiffness (B), in all orientations, to the cube power of panel mass per unit surface area ( $\mu$ ) of at least 10;

a mounting means which supports the panel or attaches

to it a supporting body, in a free undamped manner;

and an electro-mechanical drive means coupled to the panel which serves to excite a multi-modal resonance in the radiator panel in response to an electrical input within a  
5 working frequency band for the loudspeaker.

There is a wide application for sound distribution using speakers in standard module form, interchangeable with commercial ceiling tiles, generally on a 600 x 600mm format, the objective being the even distribution of  
10 articulate speech and music over a large area. Some conventional moving coil drivers and panel derivatives are presently made for this application.

Existing technology uses cone type moving coil speakers fitted into frames and acoustic baffles. While  
15 commonly used due to moderate cost and ready availability, these suffer from serious hot spot (excessive sound intensity) and directional effects and consequently poorer intelligibility off axis. Many units are required to give a uniform coverage over larger area.

20 Another known development uses a cone type speaker where the 'cone' is a polystyrene structure with a flat front surface, which may be painted. Here a combination of additional moving coil drivers fitted to their diaphragm, the latter structured to shrink acoustically with  
25 increasing frequency, may give a wider radiation pattern than a conventional cone speaker. These polystyrene foam speaker units require chassis and acoustic baffles for mounting them in position.

DISCLOSURE OF INVENTION

Embodiments of the present invention use members of nature, structure and configuration achievable generally and/or specifically by implementing teachings of our co-  
5 pending PCT application No. (our case P.5711) of even date herewith. Such members thus have capability to sustain and propagate input vibrational energy by bending waves in operative area(s) extending transversely of thickness often but not necessarily to edges of the member(s); are  
10 configured with or without anisotropy of bending stiffness to have resonant mode vibration components distributed over said area(s) beneficially for acoustic coupling with ambient air; and have predetermined preferential locations or sites within said area for transducer means,  
15 particularly operationally active or moving part(s) thereof effective in relation to acoustic vibrational activity in said area(s) and signals, usually electrical, corresponding to acoustic content of such vibrational activity. Uses are envisaged in co-pending International application No. (our  
20 file P.5711) for such members as or in "passive" acoustic devices without transducer means, such as for reverberation or for acoustic filtering or for acoustically "voicing" a space or room; and as or in "active" acoustic devices with transducer means, such as in a remarkably wide range of  
25 sources of sound or loudspeakers when supplied with input signals to be converted to said sound, or in such as microphones when exposed to sound to be converted into other signals.

This invention is particularly concerned with active acoustic devices in the form of loudspeakers the purpose of use in a suspended ceiling tile.

Members as above are herein called distributed mode  
5 radiators and are intended to be characterised as in the said PCT application and/or otherwise as specifically provided herein.

The invention is a ceiling tile for a suspended ceiling and incorporating a loudspeaker, characterised in  
10 that the tile is in the form of a distributed mode acoustic radiator, and by a transducer mounted wholly and exclusively on the radiator to vibrate the radiator to cause it to resonate. A resilient suspension may be disposed at the periphery of the radiator and by which the  
15 radiator is supported in the suspended ceiling.

The radiator may be a stiff lightweight panel comprising a cellular core sandwiched by high modulus skins.

#### BRIEF DESCRIPTION OF DRAWINGS

20 The invention is diagrammatically illustrated, by way of example, in the accompanying drawings, in which:-

Figure 1 is a diagram showing a distributed-mode loudspeaker as described and claimed in our co-pending International application No... (our case P.5711);

25 Figure 2a is a partial section on the line A-A of Figure 1;

Figure 2b is an enlarged cross-section through a distributed mode radiator of the kind shown in Figure 2a

and showing two alternative constructions;

Figure 3a is a perspective diagram of a room incorporating a suspended ceiling, and

5 Figure 3b is a cross-sectioned side view of an embodiment of distributed-mode loudspeaker according to the present invention in the form of a ceiling tile.

BEST MODES FOR CARRYING OUT THE INVENTION

Referring to Figure 1 of the drawings, there is shown a panel-form loudspeaker (81) of the kind described and claimed in our co-pending International application No. (our case P.5711) of even date herewith comprising a  
5 rectangular frame (1) carrying a resilient suspension (3) round its inner periphery which supports a distributed mode sound radiating panel (2). A transducer (9) e.g. as described in detail with reference to our co-pending International applications Nos. (our cases P.5683/4/5) of  
10 even date herewith, is mounted wholly and exclusively on or in the panel (2) at a predetermined location defined by dimensions  $x$  and  $y$ , the position of which location is calculated as described in our co-pending International application No. (our case P.5711) of even date herewith,  
15 to launch bending waves into the panel to cause the panel to resonate to radiate an acoustic output.

The transducer (9) is driven by a signal amplifier (10), e.g. an audio amplifier, connected to the transducer by conductors (28). Amplifier loading and power  
20 requirements can be entirely normal, similar to

conventional cone type speakers, sensitivity being of the order of 86 - 88dB/watt under room loaded conditions. Amplifier load impedance is largely resistive at 6 ohms, power handling 20-80 watts. Where the panel core and/or skins are of metal, they may be made to act as a heat sink for the transducer to remove heat from the motor coil of the transducer and thus improve power handling.

Figures 2a and 2b are partial typical cross-sections through the loudspeaker (81) of Figure 1. Figure 2a shows that the frame (1), surround (3) and panel (2) are connected together by respective adhesive-bonded joints (20). Suitable materials for the frame include lightweight framing, e.g. picture framing of extruded metal e.g. aluminium alloy or plastics. Suitable surround materials include resilient materials such as foam rubber and foam plastics. Suitable adhesives for the joints (20) include epoxy, acrylic and cyano-acrylate etc. adhesives.

Figure 2b illustrates, to an enlarged scale, that the panel (2) is a rigid lightweight panel having a core (22) e.g. of a rigid plastics foam (97) e.g. cross linked polyvinylchloride or a cellular matrix (98) i.e. a honeycomb matrix of metal foil, plastics or the like, with the cells extending transversely to the plane of the panel, and enclosed by opposed skins (21) e.g. of paper, card, plastics or metal foil or sheet. Where the skins are of plastics, they may be reinforced with fibres e.g. of carbon, glass, Kevlar (RTM) or the like in a manner known per se to increase their modulus.

Envisaged skin layer materials and reinforcements thus include carbon, glass, Kevlar (RTM), Nomex (RTM) i.e. aramid etc. fibres in various lays and weaves, as well as paper, bonded paper laminates, melamine, and various  
5 synthetic plastics films of high modulus, such as Mylar (RTM), Kaptan (RTM), polycarbonate, phenolic, polyester or related plastics, and fibre reinforced plastics, etc. and metal sheet or foil. Investigation of the Vectra grade of liquid crystal polymer thermoplastics shows that they may  
10 be useful for the injection moulding of ultra thin skins or shells of smaller size, say up to around 30cm diameter. This material self forms an orientated crystal structure in the direction of injection, a preferred orientation for the good propagation of treble energy from the driving point to  
15 the panel perimeter.

Additional such moulding for this and other thermoplastics allows for the mould tooling to carry location and registration features such as grooves or rings for the accurate location of transducer parts e.g. the  
20 motor coil, and the magnet suspension. Additional with some weaker core materials it is calculated that it would be advantageous to increase the skin thickness locally e.g. in an area or annulus up to 150% of the transducer diameter, to reinforce that area and beneficially couple  
25 vibration energy into the panel. High frequency response will be improved with the softer foam materials by this means.

Envisaged core layer materials include fabricated

honeycombs or corrugations of aluminium alloy sheet or foil, or Kevlar (RTM), Nomex (RTM), plain or bonded papers, and various synthetic plastics films, as well as expanded or foamed plastics or pulp materials, even aerogel metals  
5 if of suitably low density. Some suitable core layer materials effectively exhibit usable self-skinning in their manufacture and/or otherwise have enough inherent stiffness for use without lamination between skin layers. A high performance cellular core material is known under the trade  
10 name 'Rohacell' which may be suitable as a radiator panel and which is without skins. In practical terms, the aim is for an overall lightness and stiffness suited to a particular purpose, specifically including optimising contributions from core and skin layers and transitions  
15 between them.

Several of the preferred formulations for the panel employ metal and metal alloy skins, or alternatively a carbon fibre reinforcement. Both of these, and also designs with an alloy Aerogel or metal honeycomb core, will  
20 have substantial radio frequency screening properties which should be important in several EMC applications. Conventional panel or cone type speakers have no inherent EMC screening capability.

In addition the preferred form of piezo and electro  
25 dynamic transducers have negligible electromagnetic radiation or stray magnet fields. Conventional speakers have a large magnetic field, up to 1 metre distant unless specific compensation counter measures are taken.

Where it is important to maintain the screening in an application, electrical connection can be made to the conductive parts of an appropriate DML panel or an electrically conductive foam or similar interface may be used for the edge mounting.

The suspension (3) may damp the edges of the panel (2) to prevent excessive edge movement of the panel. Additionally or alternatively, further damping may be applied, e.g. as patches, bonded to the panel in selected positions to damp excessive movement to distribute resonance equally over the panel. The patches may be of bitumen-based material, as commonly used in conventional loudspeaker enclosures or may be of a resilient or rigid polymeric sheet material. Some materials, notably paper and card, and some cores may be self-damping. Where desired, the damping may be increased in the construction of the panels by employing resiliently setting, rather than rigid setting adhesives.

Effective said selective damping includes specific application to the panel including its sheet material of means permanently associated therewith. Edges and corners can be particularly significant for dominant and less dispersed low frequency vibration modes of panels hereof. Edge-wise fixing of damping means can usefully lead to a panel with its said sheet material fully framed, though their corners can often be relatively free, say for desired extension to lower frequency operation. Attachment can be by adhesive or self-adhesive materials. Other forms of

useful damping, particularly in terms of more subtle effects and/or mid- and higher frequencies can be by way of suitable mass or masses affixed to the sheet material at predetermined effective medial localised positions of said  
5 area.

An acoustic panel as described above is bi-directional. The sound energy from the back is not strongly phase related to that from the front. Consequently there is the benefit of overall summation of  
10 acoustic power in the room, sound energy of uniform frequency distribution, reduced reflective and standing wave effects and with the advantage of superior reproduction of the natural space and ambience in the reproduced sound recordings.

15 While the radiation from the acoustic panel is largely non-directional, the percentage of phase related information increases off axis. For improved focus for the phantom stereo image, placement of the speakers, like pictures, at the usual standing person height, confers the  
20 benefit of a moderate off-axis placement for the normally seated listener optimising the stereo effect. Likewise the triangular left/right geometry with respect to the listener provides a further angular component. Good stereo is thus obtainable.

25 There is a further advantage for a group of listeners compared with conventional speaker reproduction. The intrinsically dispersed nature of acoustic panel sound radiation gives it a sound volume which does not obey the

inverse square law for distance for an equivalent point source. Because the intensity fall-off with distance is much less than predicted by inverse square law then consequently for off-centre and poorly placed listeners the intensity field for the panel speaker promotes a superior stereo effect compared to conventional speakers. This is because the off-centre placed listener does not suffer the doubled problem due to proximity to the nearer speaker; firstly the excessive increase in loudness from the nearer speaker, and then the corresponding decrease in loudness from the further loudspeaker.

There is also the advantage of a flat, lightweight panel-form speaker, visually attractive, of good sound quality and requiring only one transducer and no crossover for a full range sound from each panel diaphragm.

Figure 3 illustrates a ceiling tile (36) of the kind adapted to be supported in a grid-like suspended frame (99) to form a suspended ceiling, and which is formed as a loudspeaker (81) of the kind shown in Figures 1 and 2, that is to say comprising a stiff, lightweight multi-mode resonating panel (2) having a core (22) enclosed by skins (21) on both sides. The panel (2) is mounted at its periphery on a resilient suspension (3) of foam rubber which is supported on the frame (99). The suspension (3) may be attached to either the panel (2) or to the frame (99) by means of an adhesive, but the connection may be by gravity alone. The panel (2) carries a transducer (9), e.g. of the kind shown in Figures 7 to 12, to launch

bending waves into the panel to cause it to resonate to produce an acoustic output. The transducer (9) may be positioned on the panel as described in our co-pending International No. (our file P.5711).

5 In a preferred example of good quality the acoustic panel is made as an expanded polystyrene foam core of typically 100g/m<sup>3</sup> density, 8mm thick, skinned with hardened aluminium alloy skins of 0.1mm. A soft foam or felt strip, some 3mm thick is fixed to the perimeter to provide a  
10 partially compliant mounting when placed in the ceiling frames and also helps to suppress any possible vibration in the ceiling framing sections.

A preferred form of excitations is a unitary moving coil inertial transducer with a 25mm or 38mm voice coil, 6  
15 ohms impedance, 40 watt power handling, with the coil bonded directly to the panel surface. A compact cup type magnet system enclosed and self sealing may also be bonded directly to the panel via a resilient decoupling ring chosen for its vibro-mechanical properties and dimensional  
20 stability.

Depending on application, a low cost form ceiling tile can be made with a plastics foam cored paper faced board material, which may have a light alloy foil layer for fire retardancy, driven by low cost piezo vibration exciters.  
25 Reduced maximum sound levels are obtained, still more than sufficient for personnel announcements, voice overs and background music distribution. The wide area coverage is maintained.

When metallic or carbon conductive skins or cores are employed the speaker may be earth bonded or grounded to maintain EMC screening of an installed structure.

#### INDUSTRIAL APPLICABILITY

5       A ceiling tile loudspeaker according to the present invention does not require a frame, chassis, or acoustic baffle. The entire speaker panel is unitary and may be placed in position just like a passive decorative ceiling tile. The acoustic panel is relatively lightweight,  
10       reducing ceiling loadings and aiding installation. It may readily be made fire resistant. It can be decorated, painted or papered to render it invisible in a ceiling installation without significant acoustic impairment.

Minor damage does not impair the performance as  
15       compared with the diaphragms of cone type speakers which are very fragile. Also important is the great advantage in sound distribution given by the acoustic panel speaker. Its combination of high intelligibility and wide angle coverage means that in a typical large area installation  
20       superior acoustic performance may be achieved with around half the number of conventional installed loudspeakers, with a great saving in installed cost.

CLAIMS

1. A suspended ceiling tile incorporating a loudspeaker, characterised in that the tile comprises a distributed mode acoustic radiator, and by a transducer mounted wholly and  
5 exclusively on the radiator to vibrate the radiator to cause it to resonate.
2. A suspended ceiling tile according to claim 1, characterised by a resilient suspension disposed at the periphery of the radiator to support the radiator in a  
10 suspended ceiling.
3. A suspended ceiling tile according to claim 1 or claim 2, characterised in that the radiator is a stiff lightweight panel comprising a cellular core sandwiched by high modulus skins.
- 15 4. A suspended ceiling tile according to claim 3, characterised in that the cellular core is of foamed plastics.
5. A suspended ceiling tile according to any preceding claim, characterised in that the transducer is an inertial  
20 vibration transducer.

1/3

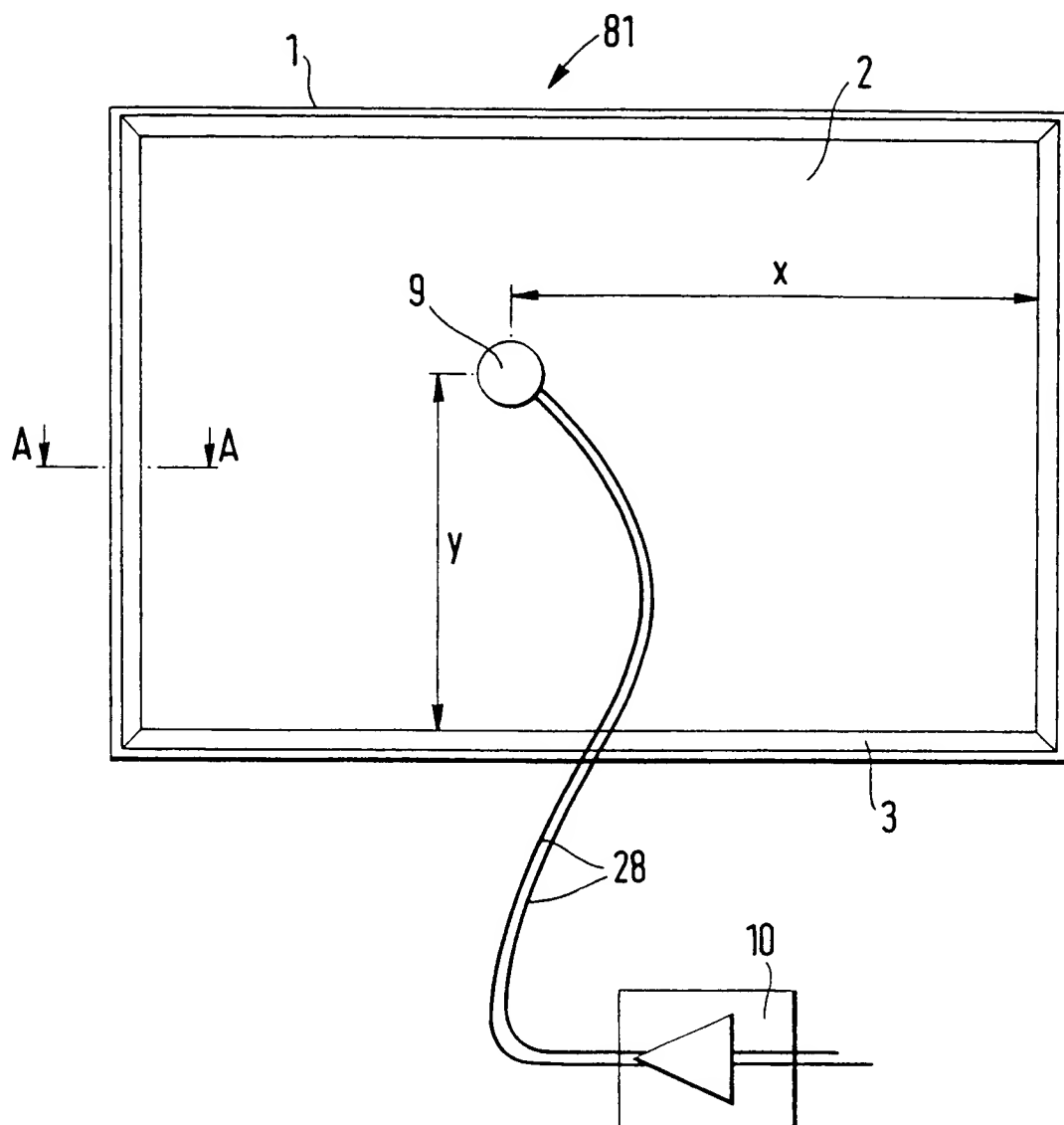


Fig. 1

SUBSTITUTE SHEET (RULE 26)

2/3

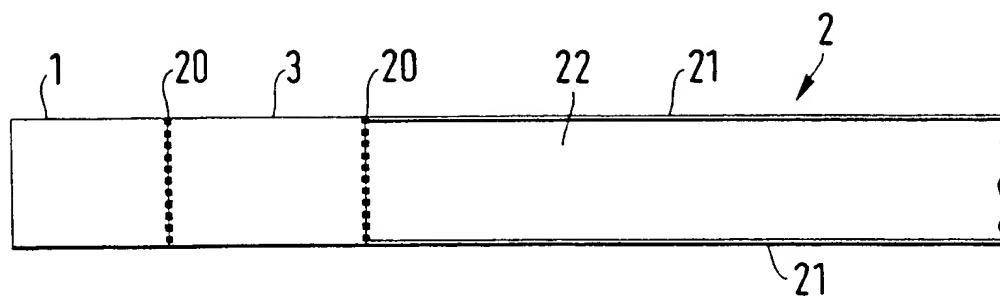


Fig. 2a

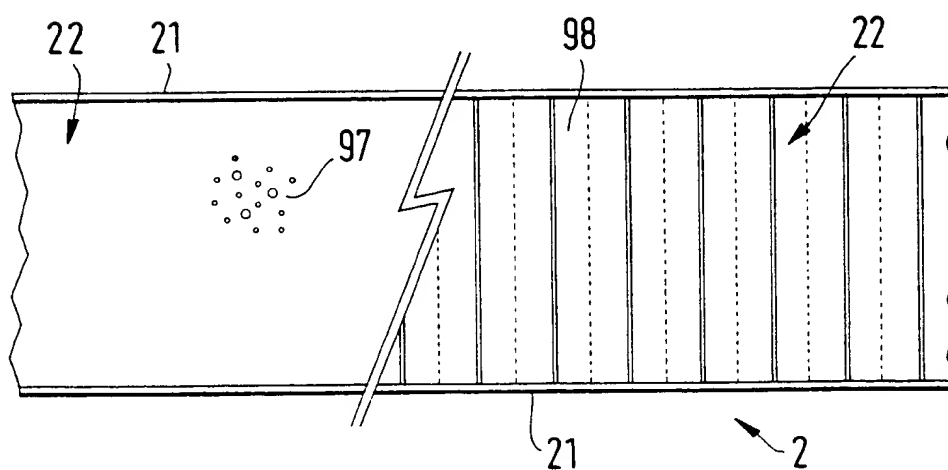


Fig. 2b

SUBSTITUTE SHEET (RULE 26)

3/3

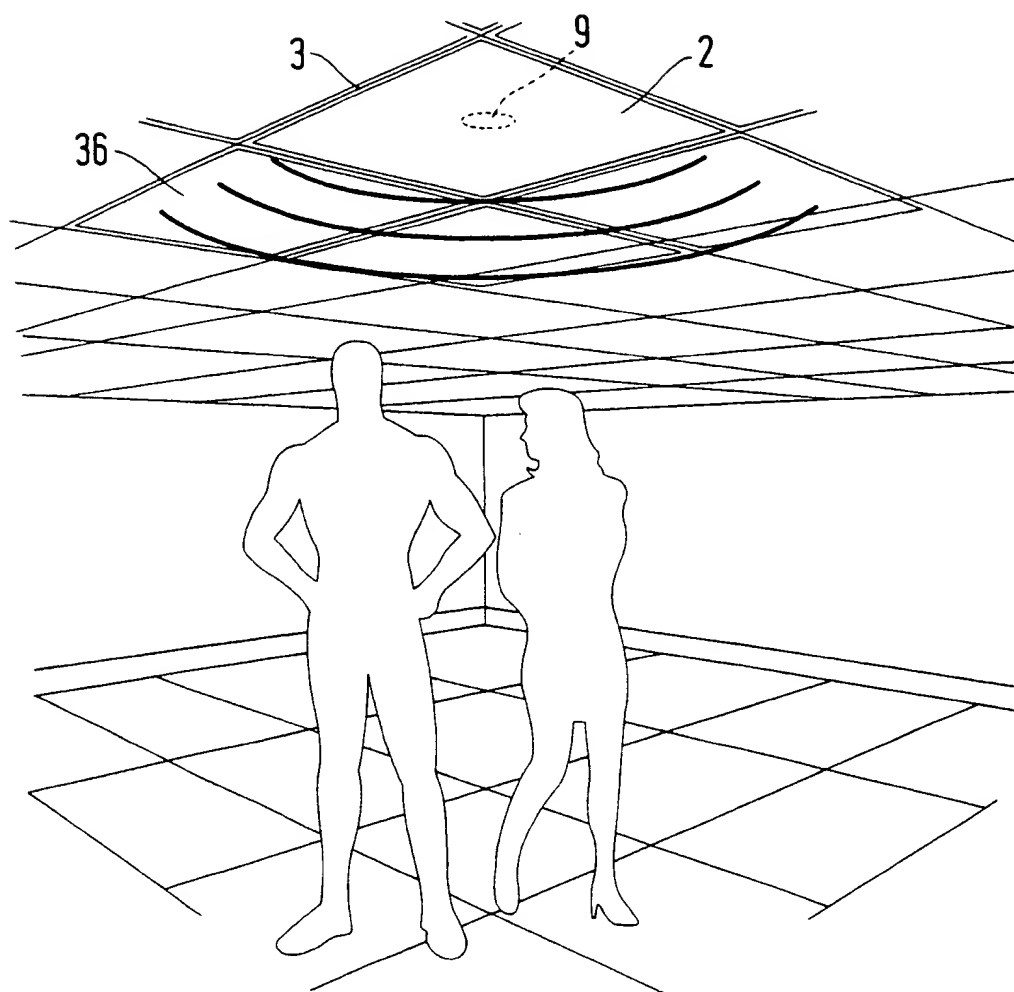


Fig. 3a

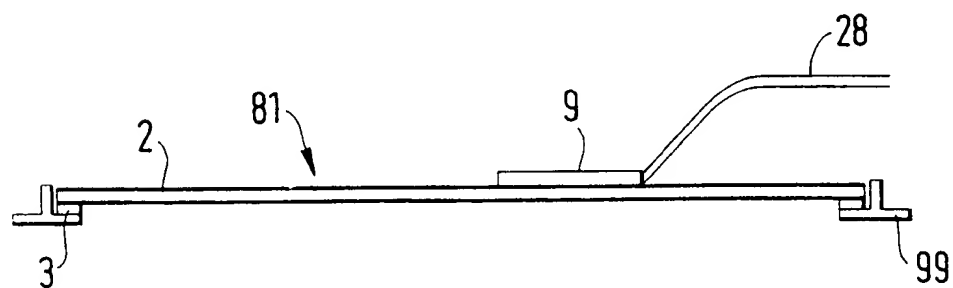


Fig. 3b

SUBSTITUTE SHEET (RULE 26)

# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/GB 96/02153

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 6 H04R1/02 H04R7/06 H04R9/06

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 6 H04R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 247 925 A (WARNAKA) 26 April 1966 see column 3, line 31 - line 34 ---	1
A	US 4 392 027 A (BOCK) 5 July 1983 see column 2, line 36 - column 4, line 21 ---	1-3,5
A	US 4 928 312 A (HILL) 22 May 1990 see column 2, line 10 - column 4, line 68; figures ---	1,4
A	WO 92 03024 A (SECR DEFENCE BRIT) 20 February 1992 see page 5, line 4 - page 6, line 5; figures ---	1
A	& GB 2 262 861 A (SECR DEFENSE) 30 June 1993 cited in the application -----	1

☐ Further documents are listed in the continuation of box C.

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Date of the actual completion of the international search

3 February 1997

Date of mailing of the international search report

13.02.97

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Authorized officer

Gastaldi, G

# INTERNATIONAL SEARCH REPORT

Information on patent family members

Internat Application No  
PCT/GB 96/02153

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		GB-A,B 2020509	14-11-79
US-A-4928312	22-05-90	NONE	
WO-A-9203024	20-02-92	GB-A- 2246684	05-02-92
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		DE-D- 69106712	23-02-95
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		GB-A,B 2262861	30-06-93
		JP-T- 5509211	16-12-93



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification <sup>6</sup> :</b>  <b>H04R 7/06, 9/06, G06F 1/16</b>	<b>A1</b>	<b>(11) International Publication Number:</b> <b>WO 99/65274</b>  <b>(43) International Publication Date:</b> 16 December 1999 (16.12.99)
<b>(21) International Application Number:</b> PCT/GB99/01748  <b>(22) International Filing Date:</b> 3 June 1999 (03.06.99)  <b>(30) Priority Data:</b> 9812225.2                      5 June 1998 (05.06.98)                      GB  <b>(71) Applicant (for all designated States except US):</b> NEW TRANS- DUCERS LIMITED [GB/GB]; Ixworth House, 37 Ixworth Place, London SW3 3QH (GB).  <b>(72) Inventor; and</b> <b>(75) Inventor/Applicant (for US only):</b> BANK, Graham [GB/GB]; 1 Boartree Way, Huntingdon, Cambridgeshire PE18 6GL (GB).  <b>(74) Agent:</b> MAGUIRE BOSS; 5 Crown Street, St. Ives, Cam- bridgeshire PE17 4EB (GB).		<b>(81) Designated States:</b> AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).  <b>Published</b> <i>With international search report.</i> <i>Before the expiration of the time limit for amending the</i> <i>claims and to be republished in the event of the receipt of</i> <i>amendments.</i>
<b>(54) Title:</b> RESONANT PANEL-FORM ACOUSTIC DEVICES  <div style="text-align: center;"> </div> <b>(57) Abstract</b>  A resonant panel-form acoustic device comprising a resonant panel-form member and a vibration exciter mounted to the panel-form member to apply bending wave energy thereto to cause the member to resonate to produce an acoustic output, wherein the vibration exciter is adapted to act as a carrier for the panel-form member.		

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5

## RESONANT PANEL-FORM ACOUSTIC DEVICES

10

DESCRIPTION

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FIELD OF THE INVENTION

This invention relates to acoustic devices and more particularly to resonant panel-form acoustic devices such as loudspeakers.

BACKGROUND TO THE INVENTION

20 International patent application WO97/09842 describes resonant panel-form acoustic devices now known as 'distributed mode' or 'DM' devices including loudspeakers.

Particularly successful types and specific structures of transducers or vibration exciters for applying bending  
25 wave energy to panel-form members to cause resonance include those of so-called inertial nature.

It has been of particular practical value in prior distributed mode loudspeaker applications for the vibration

exciters to be attached directly to loudspeaker panel members without need for additional support for the exciters. This practice is logical as well as successful in cases where the exciter mass is less than the mass of the panel member, including where the panel member is supported by local framing or some equivalent suspension. Also, such panel-suspended exciters have potential for beneficial resonance according to a second order characteristic effective to extend the low frequency response. A very different situation arises for much smaller distributed mode panel members, where a point can be reached at which panel member mass is of the same order or even less than that of the mass of the exciter, perhaps especially for electro-dynamic type exciters which have significant mass due to the magnet and magnet poles. Considerations of panel strength, resistance to impact shock etc. become important; and it is an object of this invention to provide a novel and advantageous solution.

#### SUMMARY OF THE INVENTION

According to the invention a resonant panel-form acoustic device comprises a resonant panel-form member and a vibration exciter mounted to the panel-form member to apply bending wave energy thereto to cause the member to resonate to produce an acoustic output, wherein the vibration exciter is adapted to act as a carrier for the panel-form member. In this way the vibration exciter acts as a mount for the panel-form member, rather than the exciter being mounted on the panel-form member as was

previously proposed. The vibration exciter may in turn be mounted on a host system, e.g. a loudspeaker stand or bracket or electronic apparatus such as a laptop computer.

In one embodiment, a small light distributed mode  
5 panel member is effectively free other than for its association with the vibration exciter which constitutes the means of mounting/attachment of the complete loudspeaker assembly.

Interestingly, for such a fixed or grounded vibration  
10 exciter, the high-pass function will now be first order, typically with a roll-off at about 6dB/octave; and the panel member design in respect of local acoustic loading and lowest bending frequency can usefully be adjusted to take this into account. There is, of course, clear benefit  
15 where low frequency roll-off of about 6dB/octave is a design objective.

Although the invention provides that the structure of the vibration exciter affords basic support and stability for a resonant panel member, particularly for light-weight  
20 panel members, additional framing and/or suspension of the panel member may be provided if appropriate and desired, whether for stability or for defining/controlling desired vibration conditions in/for the panel member, or both, perhaps particularly in or as to contributions of  
25 peripheral/marginal regions, including from partial up to substantially full sealing of the panel member into a baffle. The availability of additional acoustic control by separating the front acoustic output from the rear acoustic

output of the panel may be beneficial in certain applications.

#### BRIEF INTRODUCTION TO THE DRAWINGS

Exemplary specific implementation will now be  
5 described with reference to the accompanying diagrammatic drawings, in which:

Figures 1A,B and C are respectively a rear plan, and a partial sectional side view of a prior art resonant panel-form loudspeaker together with a graphical idealised  
10 acoustic output/response curve, and

Figures 2A to C correspond respectively to those of Figures 1A to 1C and show a resonant panel-form loudspeaker embodying the present invention.

#### DESCRIPTION OF ILLUSTRATED EMBODIMENTS

15 Referring first to Figures 1A-C, a prior art panel-form distributed mode loudspeaker 10 comprises a suitable resonant panel member 11 mounted at its edges by means of resilient suspension members 12A to D in a frame 19. An inertial electrodynamic vibration exciter 13 is shown  
20 mounted and supported wholly on the panel member 11 to excite the panel into resonance to produce an acoustic output.

Specifically, the exciter 13 comprises a moving coil  
15 rigidly connected at connection 14 to the panel 11. The  
25 moving coil 15 is arranged in the annular gap 17A of a magnet assembly 16,17 comprising a magnet 16 sandwiched between a pair of pole-pieces 17 and having suitably compliant suspension 18 connected between the magnet

assembly and the panel member 11. In general, the panel member 11 will have more, often significantly more, mass than the exciter 13, particularly the magnet assembly 16,17 as the highest mass component thereof. Indicated frequency-dependent roll-off of loudspeaker output A is at least 12dB/octave below the region (Fe) of exciter resonance. Such an arrangement is disclosed in WO97/09842.

Turning to Figures 2A to C, a panel-form resonant loudspeaker 20 embodying this invention comprises a suitable resonant panel member 21 shown with a generally similar relationship with a vibration exciter 23 generally in accordance with the teaching in WO97/09842 and reference numerals 24 to 28 generally correspond to reference numerals 14 to 18 of Figure 1B.

15 In this case, however, the panel member 21 is of the same order or even less mass than the exciter 23 or highest mass part(s) thereof, namely the magnet assembly comprising the magnet 26 and associated pole-pieces 27. The magnet assembly 26,27 is arranged actually to carry the panel member 21, rather than vice versa as is the case in the prior art arrangement. Moreover, the magnet assembly 26,27 is the means by which the loudspeaker 20 as a whole is mounted, see bond 29 between a rear face 31 of the exciter magnet assembly and a mounting structure 30 to support the  
20 member 21, rather than vice versa as is the case in the prior art arrangement. Moreover, the magnet assembly 26,27 is the means by which the loudspeaker 20 as a whole is mounted, see bond 29 between a rear face 31 of the exciter magnet assembly and a mounting structure 30 to support the  
25 loudspeaker in position on a host apparatus, e.g. a loudspeaker stand or the structure or casing of electronic apparatus.

As illustrated, and in complete contrast to practice

hitherto, the panel member 21 is effectively free, i.e. not as such suspended to any support structure other than the exciter. If desired, however, soft resilient members 22 may be connected between the edges of the panel member 21 and the mounting structure 30 to damp excessive movements of the panel edges in use.

By way of specific example, a distributed mode panel member 21 measures 2mm in thickness and approximately 2.5 x 3cm in area, and weighs only a few grams (perhaps as little as two grams or even less) compared with an electro-dynamic exciter 23 at up to about 15 grams or more. A serviceable and reliable loudspeaker assembly was designed by adhesively fixing the back face 31 of the exciter magnet assembly to a suitable area of the host apparatus (in this case the interior face of the lid of a laptop computer) and allowing the panel to operate freely on the coil suspension of the exciter. The loudspeaker was obscured behind a grille in the lid.

The damping and related material properties of this DM panel can particularly suit use as described, its smallness giving rise to boundary conditions in the exciter region which provide some modal termination which by prior practice would have had to be otherwise provided-for at peripheral regions of a mounted or suspended panel.

It is, of course, feasible for some degree of ancillary mounting and/or other association of the panel member 21 with other damping and/or framing means, including in association with a baffle.

As shown in Figure 2C, it is particularly noteworthy that low frequency roll-off is now much more gradual, specifically at about 6dB/octave.

CLAIMS

1. A resonant panel-form acoustic device comprising a resonant panel-form member and a vibration exciter mounted to the panel-form member to apply bending wave energy  
5 thereto to cause the member to resonate to produce an acoustic output, wherein the vibration exciter is adapted to act as a carrier for the panel-form member.
2. A resonant panel-form acoustic device according to claim 1, wherein the vibration exciter is adapted for  
10 mounting on a host system.
3. A resonant panel-form acoustic device according to claim 1 or claim 2, comprising a moving coil electro-  
dynamic vibration exciter having a magnet assembly and a voice coil movable with respect to the magnet assembly in  
15 response to an applied electrical signal, the resonant panel-form member being rigidly coupled directly to the voice coil, and comprising resilient suspension means coupled between the panel-form member and the magnet assembly to support the panel-form member.
- 20 4. A resonant panel-form acoustic device according to claim 3, wherein the magnet assembly has a face adapted to be rigidly fixed to a host system.
5. A resonant panel-form acoustic device according to any one of claims 2 to 4, comprising damping means applied  
25 between the panel-form member and the host system.
6. A loudspeaker comprising a resonant panel-form acoustic device as claimed in any preceding claim.
7. Host system comprising a loudspeaker as claimed in

claim 6.

8. A laptop computer comprising a loudspeaker as claimed in claim 6.

1/2

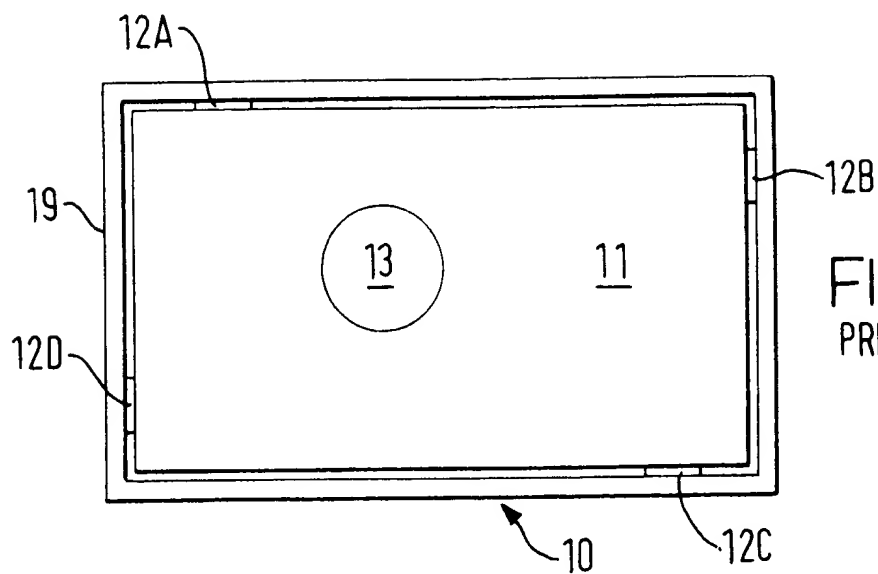


FIG. 1A  
PRIOR ART

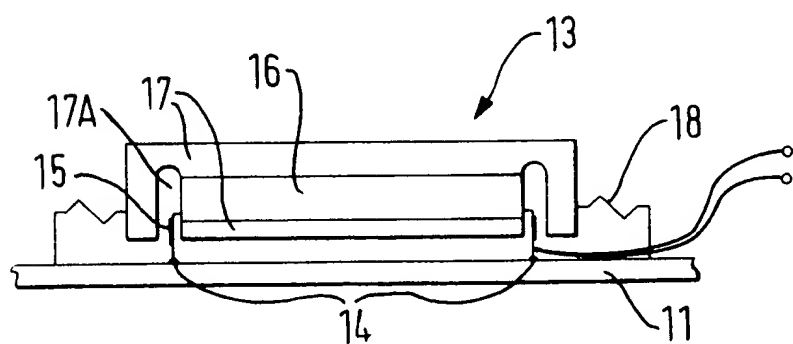


FIG. 1B  
PRIOR ART

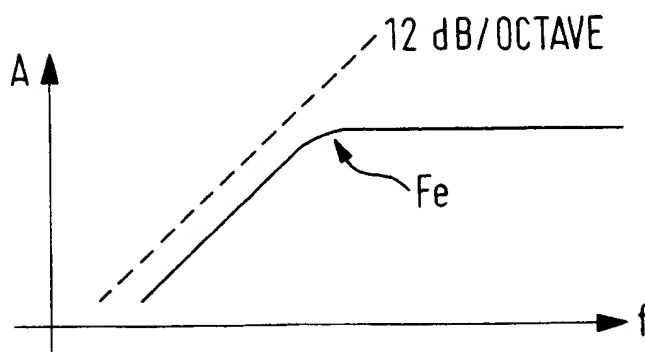


FIG. 1C  
PRIOR ART

2/2

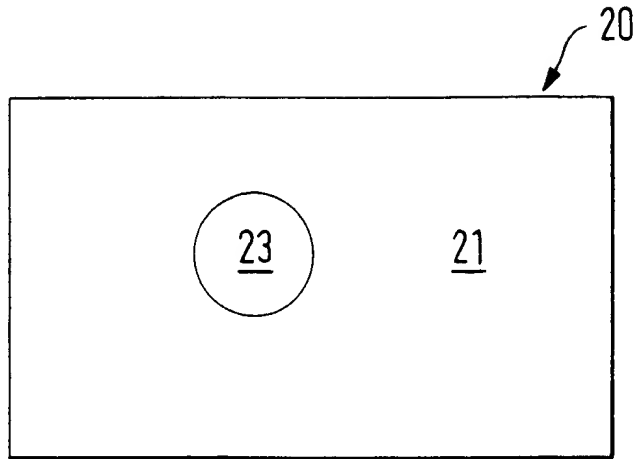


FIG. 2A

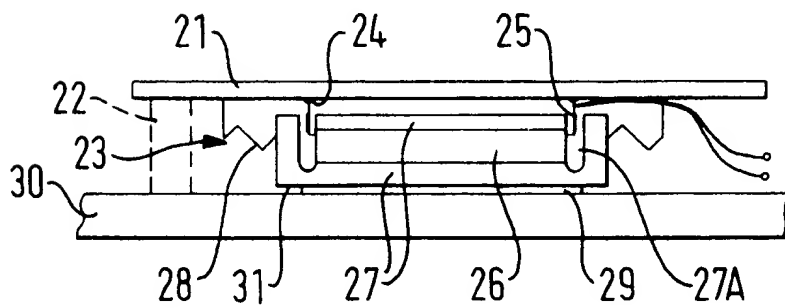


FIG. 2B

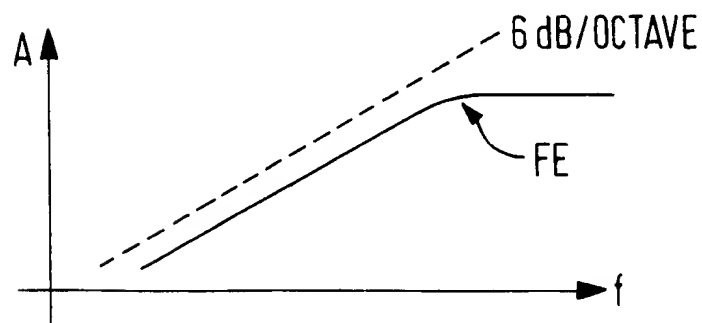


FIG. 2C

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 99/01748

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 H04R7/06 H04R9/06 G06F1/16

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 H04R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 347 335 A (WATTERS ET AL.) 17 October 1967 (1967-10-17) page 3, line 63 -page 4, line 62; figures 2,5-7	1
A	WO 97 09842 A (AZIMA HENRY ;HARRIS NEIL (GB); COLLOMS MARTIN (GB); VERITY GROUP P) 13 March 1997 (1997-03-13) cited in the application figures 11B,29	2-8
A	WO 92 03024 A (SECR DEFENCE BRIT) 20 February 1992 (1992-02-20) page 5, line 4 - line 21; figure 1	1
A	US 3 247 925 A (WARNAKA) 26 April 1966 (1966-04-26) column 3, line 5 - line 27; figures	1



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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PC1/GB 99/01748

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 99/01748

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		JP 5509211 T	16-12-1993
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## PATENT COOPERATION TREATY

PCT

NOTIFICATION OF THE RECORDING  
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From the INTERNATIONAL BUREAU

To:

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Date of mailing (day/month/year)

08 January 2001 (08.01.01)

Applicant's or agent's file reference

P.5897.WOP

International application No.

PCT/GB00/00801

## IMPORTANT NOTIFICATION

International filing date (day/month/year)

09 March 2000 (09.03.00)

1. The following indications appeared on record concerning:

☒

the applicant

☒

the inventor

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the agent

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4. A copy of this notification has been sent to:

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1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

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Lazar Joseph Panakal

Telephone No.: (41-22) 338.83.38

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16 October 2000 (16.10.00)Applicant's or agent's file reference  
P.5897.WOP

## IMPORTANT NOTIFICATION

International application No.  
PCT/GB00/00801International filing date (day/month/year)  
09 March 2000 (09.03.00)

## 1. The following indications appeared on record concerning:

☒ the applicant ☒ the inventor ☐ the agent ☐ the common representative

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## State of Residence

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<b>Date of mailing</b> (day/month/year) 17 November 2000 (17.11.00)	<b>IMPORTANT NOTIFICATION</b>
<b>Applicant's or agent's file reference</b> P.5897.WOP	
<b>International application No.</b> PCT/GB00/00801	<b>International filing date</b> (day/month/year) 09 March 2000 (09.03.00)

## 1. The following indications appeared on record concerning:

☒ the applicant      ☒ the inventor      ☐ the agent      ☐ the common representative

<b>Name and Address</b> OWEN, Neil, Simon Treewick Cottage Silver Street Buckden Cambridgeshire PE18 9TS United Kingdom	<b>State of Nationality</b> GB	<b>State of Residence</b> GB
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	<b>Teleprinter No.</b>	

## 2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

☐ the person      ☐ the name      ☒ the address      ☐ the nationality      ☐ the residence

<b>Name and Address</b> OWEN, Neil, Simon Treewick Cottage Silver Street Buckden Cambridgeshire PE19 5TS United Kingdom	<b>State of Nationality</b> GB	<b>State of Residence</b> GB
	<b>Telephone No.</b>	
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<b>International filing date</b> (day/month/year) 09 March 2000 (09.03.00)	<b>Priority date</b> (day/month/year) 10 March 1999 (10.03.99)
<b>Applicant</b> AZIMA, Henry et al	

1. The designated Office is hereby notified of its election made:



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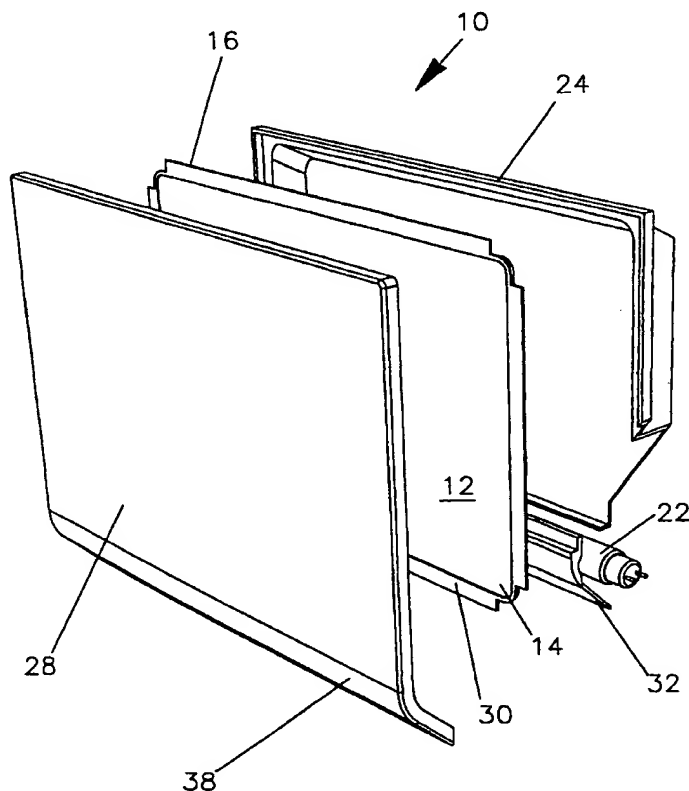
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>7</sup> : <b>H04R 1/02</b>		A1	(11) International Publication Number: <b>WO 00/54552</b>
			(43) International Publication Date: 14 September 2000 (14.09.00)
(21) International Application Number: PCT/GB00/00801 (22) International Filing Date: 9 March 2000 (09.03.00) (30) Priority Data: 9905374.6                      10 March 1999 (10.03.99)      GB 9922511.2                      24 September 1999 (24.09.99)      GB (71) Applicant (for all designated States except US): NEW TRANS-DUCERS LIMITED [GB/GB]; 37 Ixworth Place, London SW3 3QH (GB). (72) Inventors; and (75) Inventors/Applicants (for US only): AZIMA, Henry [CA/GB]; 3 Southacre Close, Chaucer Road, Cambridge CB2 2TT (GB). JARVIS, Edward [GB/GB]; 5 The Fairway, Wood End, Bluntisham, Cambridgeshire PE17 3LF (GB). OWEN, Neil, Simon [GB/GB]; Treewick Cottage, Silver Street, Buckden, Cambridgeshire PE18 9TS (GB). DUNK, Kieron [GB/GB]; 2 The Aisled Barn, Hilton, Cambridgeshire PE18 9NA (GB). (74) Agent: MAGUIRE BOSS; 5 Crown Street, St. Ives, Cambridgeshire PE17 4EB (GB).		(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).  <b>Published</b> With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.	

(54) Title: RESONANT-MODE PANEL LOUDSPEAKER WITH LIGHT EMITTER

## (57) Abstract

A combination panel-form loudspeaker/light comprising a panel (12) having a front face (14) and rear face (16), a vibration exciter (18, 20) mounted to the member to excite bending-wave vibration in the member, and a light emitter (22) mounted at or adjacent to the panel and arranged to illuminate an area adjacent to the panel.



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TITLE:

RESONANT-MODE PANEL LOUDSPEAKER WITH LIGHT EMITTER

10

DESCRIPTION

15

TECHNICAL FIELD

The invention relates to loudspeakers and more particularly to bending wave panel-form loudspeakers e.g. of the general kind described in International patent application WO97/09842.

20

BACKGROUND ART

The technology described in International Patent application WO97/09842 has come to be known as distributed mode or DM technology and among other things, WO97/09842 describes a ceiling tile/loudspeaker combination. A feature of bending wave panel-form loudspeakers is that they may be made flat and of shallow depth and may thus be

25

wall or ceiling mounted in a domestic, or other, environment to occupy a minimum of space. It has also been suggested that the flat front face of the loudspeaker may be disguised as a picture or mural.

5 It is an object of the invention to extend the utility of such wall or other surface mounting of panel-form loudspeakers for other purposes, by combining such loudspeakers with other devices in synergistic combinations.

10

#### DISCLOSURE OF INVENTION

According to the invention, there is provided a panel-form loudspeaker comprising a bending wave panel having a front face and rear face, a vibration exciter  
15 mounted to the panel to excite bending-wave vibration in the panel, and a light emitter mounted at or adjacent to the rear face of the panel and arranged to illuminate an area adjacent to the panel. A light reflector may be provided to direct light from the light emitter. The  
20 panel may be transparent or translucent.

The loudspeaker may comprise an enclosure defining a cavity enclosing at least a portion of the rear face of the panel. The light-emitter may be disposed in the cavity and may be arranged to emit light through at least  
25 one window therein. The enclosure may be transparent or translucent to light. The enclosure may be moulded from a clear plastic such as polycarbonate. The enclosure may be formed with one or more lenses to direct the emitted

light as desired. The lens(es) may be moulded integrally with the enclosure.

The enclosure is preferably acoustically opaque to prevent or reduce acoustic radiation from the rear face of the panel. The cavity may be dimensioned such as to modify the modal behaviour of the member, e.g. as taught in WO99/52322.

The light emitter may comprise a fluorescent device, or other device which does not emit significant heat. Such a device may be a low voltage device. Power to the light emitter may be supplied via electrically conductive lead(s) supplying power to the vibration exciter.

The loudspeaker may further comprise a front cover. The front cover will be acoustically transparent to allow acoustic radiation from the panel to pass through. The front cover is preferably opaque to light. The front cover may be arranged to extend beyond the panel perimeter and the enclosure. The loudspeaker may be adapted to be wall mounted or to be ceiling mounted, e.g. as a ceiling tile. Thus, when so mounted, the front cover may at least partly conceal the loudspeaker enclosure from view.

#### BRIEF DESCRIPTION OF DRAWINGS

The invention is diagrammatically illustrated, by way of example, in the accompanying drawings in which:

Figure 1 shows an exploded perspective view of a panel-form loudspeaker embodying the present invention and

intended for wall mounting;

Figure 2a is a plan view of a panel-form loudspeaker embodying the present invention and generally as shown in Figure 1;

5        Figure 2b is a cross-section along line AA of Figure 2a;

Figure 2c is a side view of the loudspeaker of Figure 2a;

Figure 3 is a cross-sectional side view of an  
10        embodiment of light fitting or tile for a suspended ceiling;

Figure 4 is a cross-sectional side view of another embodiment of light fitting or tile for a suspended ceiling;

15        Figure 5 is a cross-sectional side view of yet another arrangement of suspended ceiling light fitting or tile;

Figure 6 is a cross-sectional side view of a further embodiment of suspended ceiling light fitting or tile,  
20        and

Figure 7 is a scrap cross-sectional side view relevant to the embodiments of Figures 3 to 6

#### BEST MODES FOR CARRYING OUT THE INVENTION

25        Figures 1 and 2 of the drawings show a panel-form loudspeaker/light fitting combination (10) comprising a resonant panel (12) having a front face (14) and rear face (16) and two vibration exciters (18,20) mounted on

the panel (12) to excite bending-wave vibration in the panel (12) to cause it to resonate and produce an acoustic output generally as described in WO 97/09842.

The loudspeaker (10) further comprises a shallow rear box-like enclosure (24) which defines a cavity (26) enclosing the rear face (16) of the panel (12). The enclosure (24) is acoustically opaque to prevent or reduce acoustic radiation from the rear face (16) of the panel (12). The panel (12) is mounted to the rear enclosure by means of a resilient suspension (30) extending around the perimeter of the panel (12).

A light-emitter (22) in the form of a fluorescent tube is mounted in a support (32) in the enclosure (24) and at the lower edge thereof, as seen in Figure 1. The enclosure (24) is transparent to light and moulded from a plastics material. The support (32) for the light-emitter (22) comprises a reflector (48) which directs the emitted light as desired. In this embodiment, the loudspeaker (10) is intended for wall-mounting and thus the light is directed outwardly through the top and sides of the transparent rear enclosure (24) so that the loudspeaker also forms a wall light.

A decorative front cover (28) is mounted to the enclosure (24) to cover the front face (14) of the panel (12) and the support (32). The front cover (28) is acoustically transparent and opaque to light. Accordingly, acoustic radiation from the panel (12), but not light from the fluorescent tube, is allowed to pass through the

cover (28). A lower portion (38) of the front cover is curved to match the profile of the support (32).

The front cover (28) extends beyond the edges (42) of the rear enclosure (24) so that when the loudspeaker is wall mounted, the front cover (28) conceals the enclosure from view.

Figure 2a is a rear view of the loudspeaker with the outline of internal components, e.g. the perimeter (40) of the panel (12) and the edges (44) of the fluorescent tube shown with dotted line. The exciters (18, 20) are mounted off-centre of the panel (12) as taught in WO 97/09842. Thus the panel has the capability to sustain and propagate input vibrational energy by a plurality of resonant bending wave modes in at least one operative area extending transversely of thickness, wherein the frequencies of resonant bending wave modes are interleaved in a predetermined frequency range so that the resonant bending wave modes are substantially evenly distributed in frequency and wherein the vibration exciters are mounted on said operative area of the panel at preferential locations or sites for coupling to the resonant bending wave modes, to vibrate the panel and excite said resonant bending wave modes in the panel, the resonant bending wave modes in turn producing an acoustic output.

Figure 2b shows that the exciters (18,20) are mounted on the rear face (16) of the panel (12) and that additional support for the exciters (18,20) may be

provided by resiliently suspending them on the rear enclosure (24) e.g. as taught in W098.31188. Accordingly, the rear enclosure comprises two inward projections or bosses (46) which are aligned with the exciters (18,20),  
5 so that the resilient suspension, not shown, can be disposed between the projections (46) and the exciters.

Figure 3 shows an embodiment of light fitting or tile/loudspeaker combination (10) for a suspended ceiling (not shown) comprising a translucent resonant panel (12)  
10 having a vibration exciter (18) thereon, e.g. as taught in W097/09842 mounted in a box-like enclosure (24) to form a cavity (26) in which a fluorescent light fitting (22) is positioned. The mounting of the panel (12) in the enclosure (24) is indicated by arrows (34) and is  
15 described further with reference to Figure 7 below.

Figure 4 shows an embodiment of light fitting/loudspeaker combination (10) generally similar to that of Figure 3 and showing a vibration exciter (18) mounted on a translucent panel (12) at a position  
20 adjacent to the edge of the panel, as taught in W099/37121, whereby the exciter can be hidden from view if desired.

Figure 5 shows an arrangement of suspended ceiling/loudspeaker combination (10) light fitting  
25 generally similar to that of Figures 3 and 4 and showing the resonant panel (12) mounted above the fluorescent light (22) in the enclosure and with a ceiling tile (36) in the form of an open grille below the light fitting

(22)

Figure 6 is a cross-sectional side view of an embodiment of suspended ceiling light fitting/loudspeaker combination (10) similar to those described above in Figures 3 to 5 and comprising a box-like enclosure (24) housing a curved light reflector (48) in the form of a resonant panel (12) excited by vibration exciter (18) and with fluorescent light fitting (22) mounted below the reflector (48) and a ceiling tile (36) in the form of an open grille below the light fittings to close the enclosure (24).

Figure 7 is a scrap cross-sectional side view showing how the resonant panel (12) and/or tile (36) in the embodiments of Figures 3 to 6 can be supported in the enclosure (24) at its edges by means of brackets (50) mounted on the edges of the panel (12) or tile (36), the brackets being formed with apertures (not shown) which are located and mounted on upstanding pegs (52) in the enclosure (24).

20

#### INDUSTRIAL APPLICABILITY

The invention thus provides a slim panel-form loudspeaker of increased utility, and which can be used to provide wall or ceiling lighting.

CLAIMS

1. A combination panel-form loudspeaker/light comprising a panel having a front face and rear face, a vibration exciter mounted to the member to excite bending-wave vibration in the member, and a light emitter  
5 mounted at or adjacent to the panel and arranged to illuminate an area adjacent to the panel.
2. A combination according to claim 1, comprising a light reflector positioned to direct light from the light  
10 emitter.
3. A combination according to claim 1 or claim 2, comprising an enclosure defining a cavity enclosing at least a portion of the rear face of the member.
4. A combination according to claim 3, comprising at  
15 least one window in the enclosure and the light-emitter is disposed in the cavity and is arranged to emit light through the at least one window.
5. A combination according to claim 3, wherein the enclosure is transparent or translucent to light.
- 20 6. A combination according to claim 5 wherein the enclosure is moulded from a clear plastics.
7. A combination according to any one of claims 3 to 6 wherein the enclosure is formed with at least one lens to direct emitted light.
- 25 8. A combination according to claim 7, wherein the lens is moulded integrally with the enclosure.
9. A combination according to any one of claims 3 to 8, wherein the enclosure is acoustically opaque to prevent

or reduce acoustic radiation from the rear face of the panel.

10. A combination according to any preceding claim, wherein the panel is translucent.

5 11. A combination according to any one of claims 1 to 9, comprising an acoustically transparent front cover which is opaque to light.

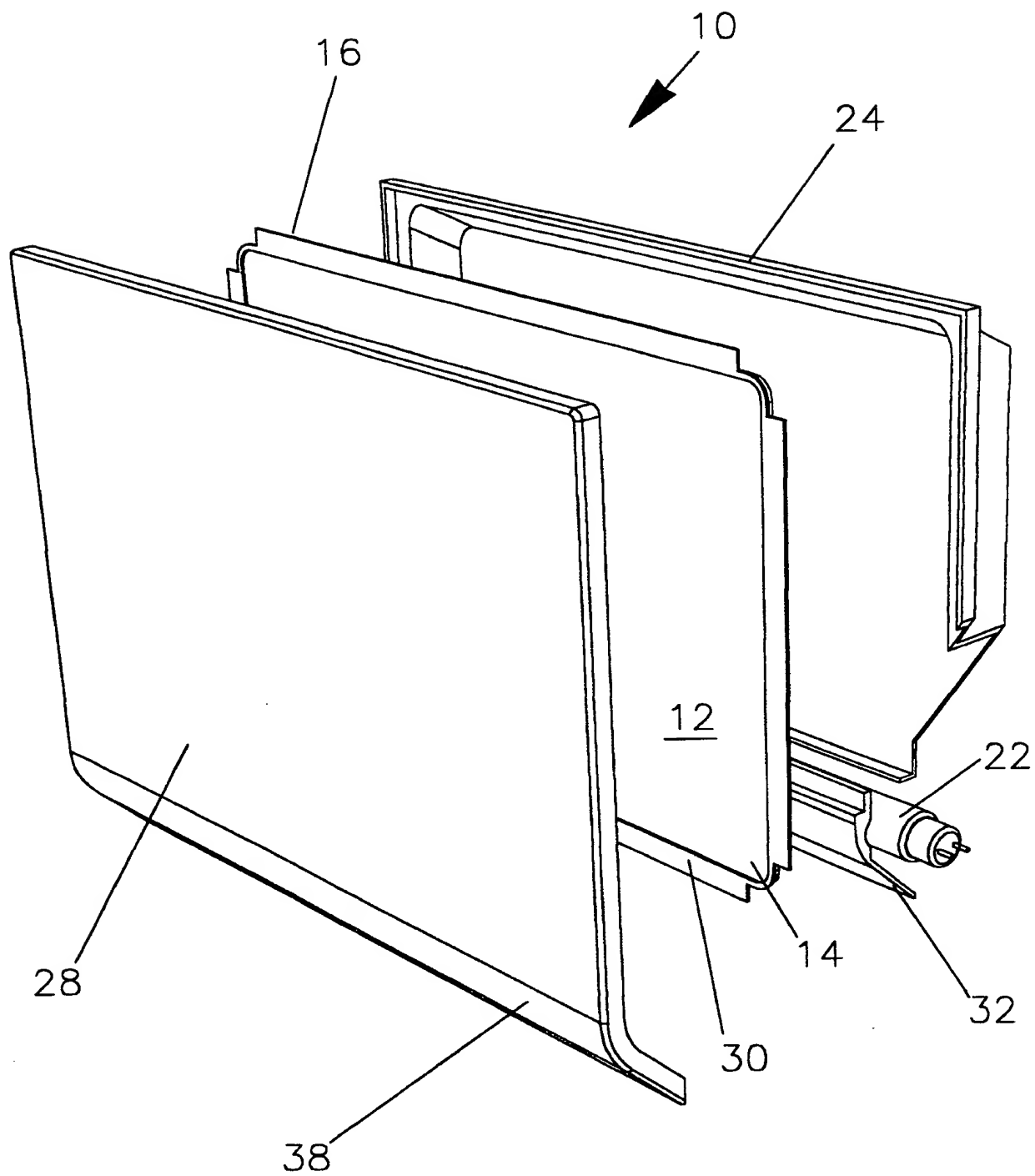
12. A combination according to claim 11, wherein the front cover is arranged to extend beyond the panel  
10 perimeter.

13. A combination according to any preceding claim, adapted to be wall mounted or to be ceiling mounted.

14. A combination according to claim 13, adapted as a fitment for a suspended ceiling.

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Figure 1



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Figure 2c

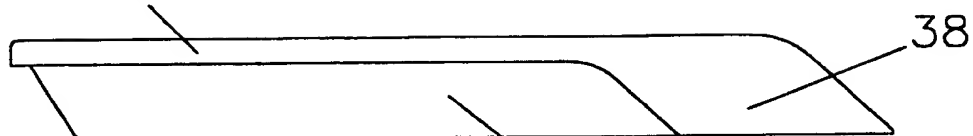


Figure 2a

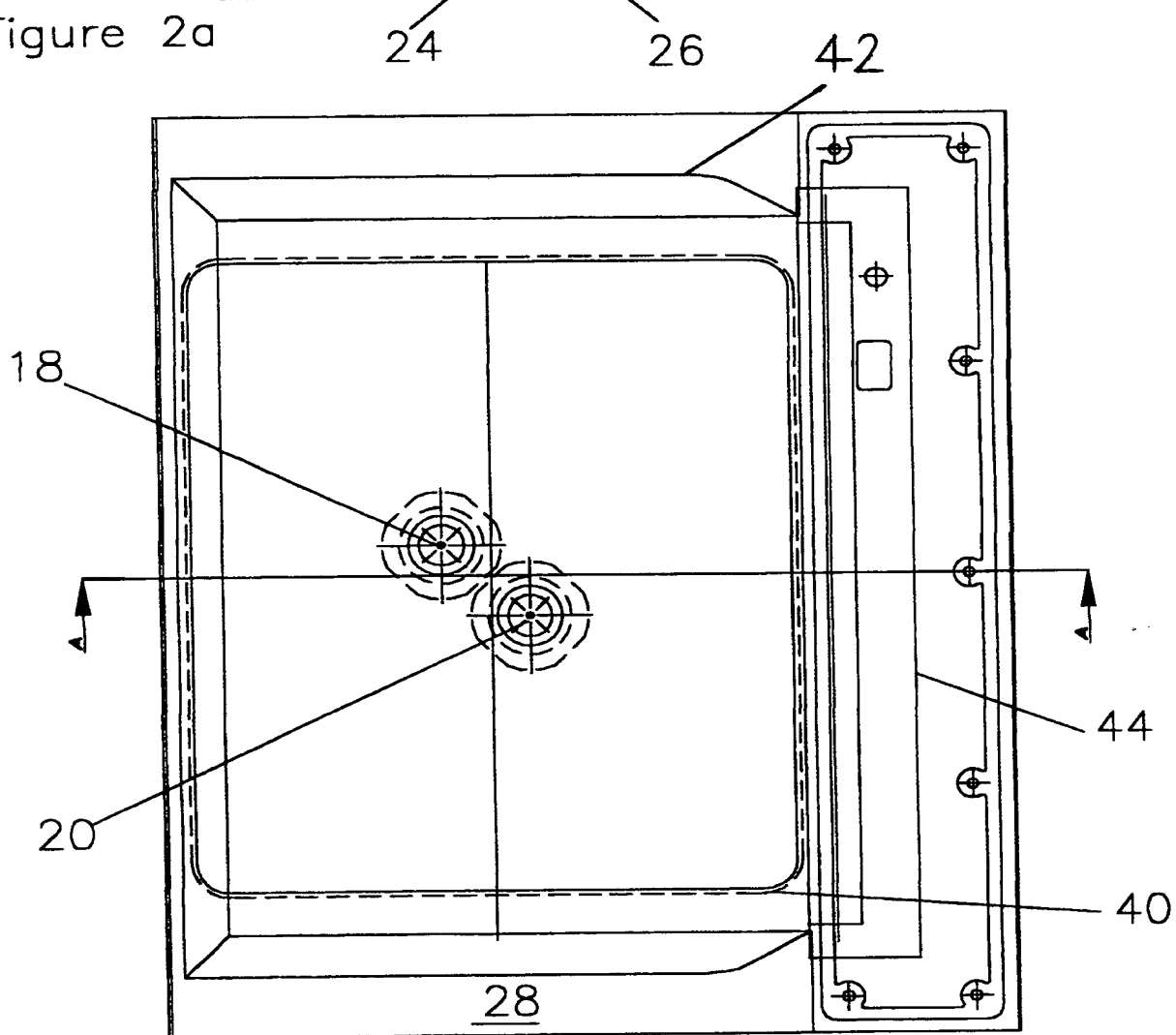
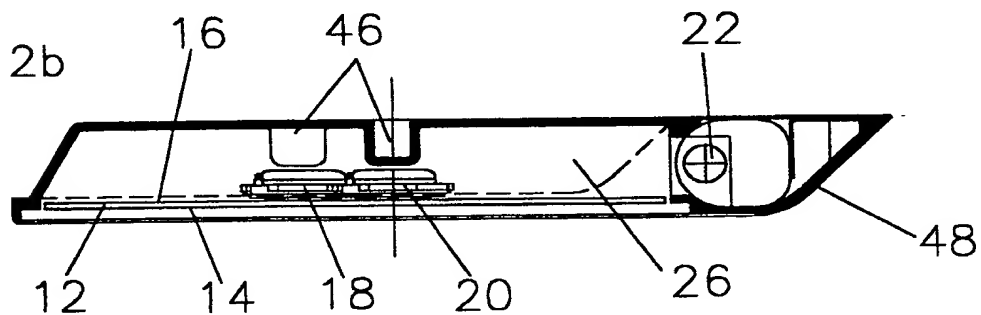


Figure 2b



3/4

Figure 3

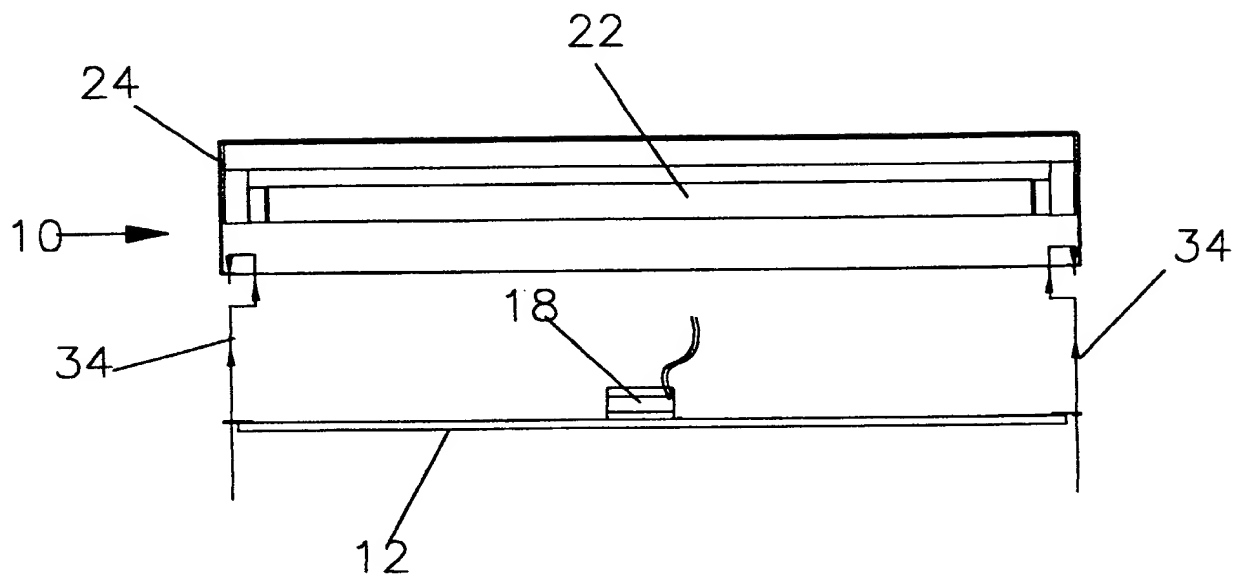


Figure 7

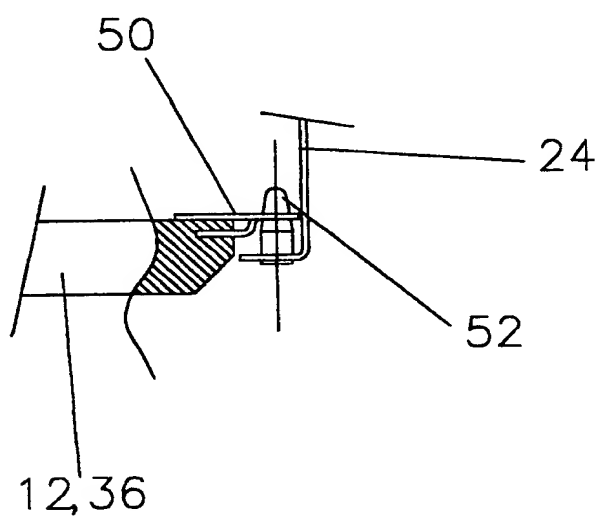


Figure 4

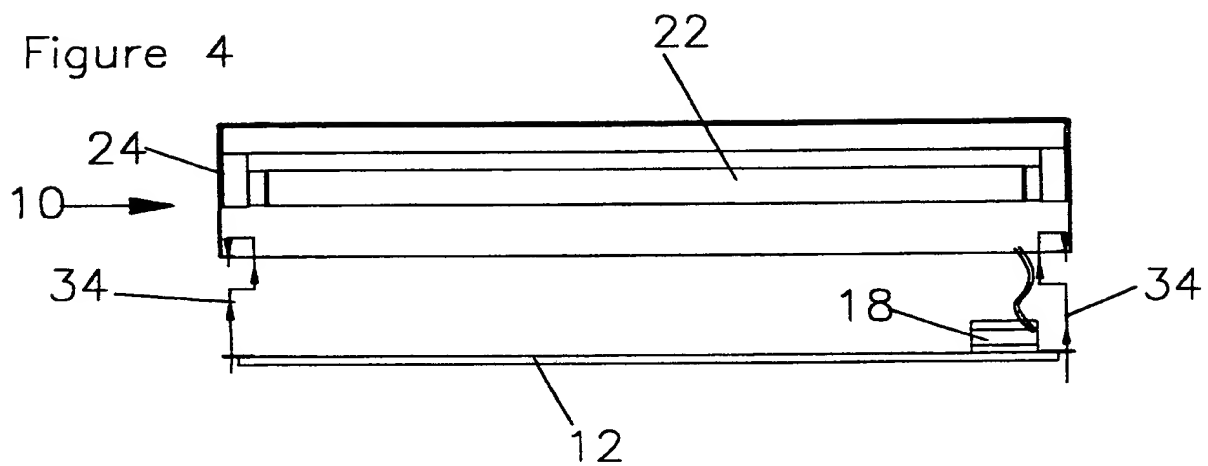


Figure 5

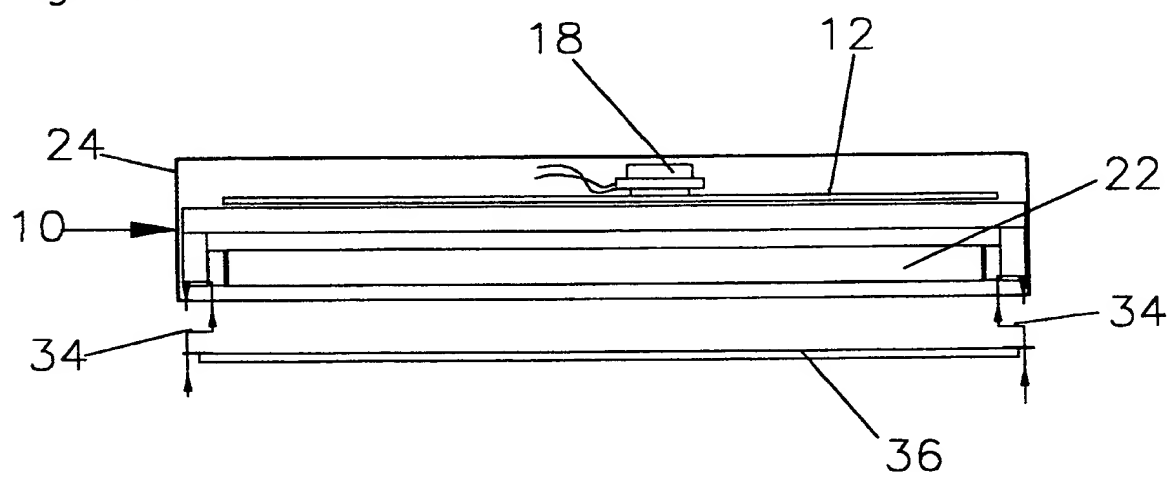
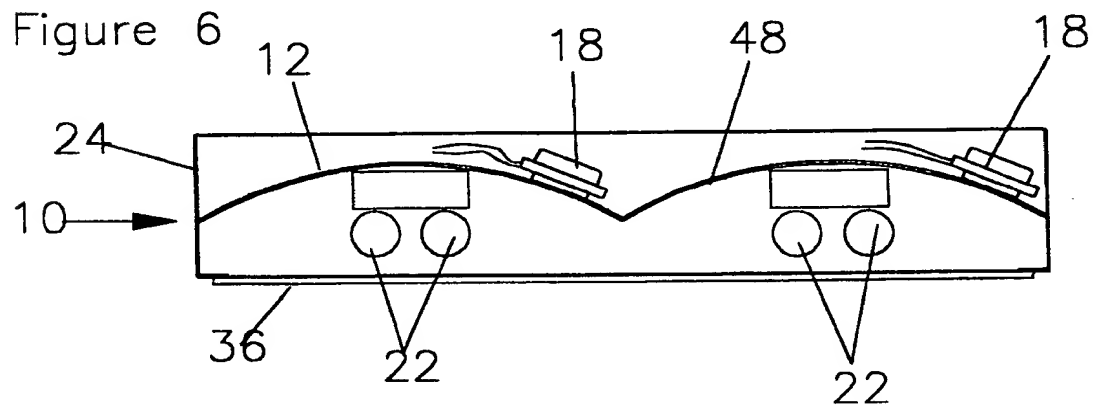


Figure 6



# INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 00/00801

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H04R1/02

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H04R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 97 09840 A (AZIMA HENRY ;HARRIS NEIL (GB); COLLOMS MARTIN (GB); VERITY GROUP P) 13 March 1997 (1997-03-13) page 6, line 5 -page 8, line 12 page 11, line 27 -page 14, line 1; figures 2A,2B,4,5	1-3,9, 11,12
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Y	US 4 559 584 A (KUWAHATA TOSHIKATSU ET AL) 17 December 1985 (1985-12-17) the whole document	4-7,10
Y	FR 2 649 575 A (THOMSON CONSUMER ELECTRONICS) 11 January 1991 (1991-01-11) page 2, line 23 -page 6, line 18; figures 1-6	4-7,10
	----- -/--	



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

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Date of the actual completion of the international search

29 June 2000

Date of mailing of the international search report

11/07/2000

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# INTERNATIONAL SEARCH REPORT

Inter. Patent Application No

PCT/GB 00/00801

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 97 09843 A (AZIMA HENRY ;HARRIS NEIL (GB); COLLOMS MARTIN (GB); VERITY GROUP P) 13 March 1997 (1997-03-13) page 6, line 8 -page 8, line 15 page 11, line 16 -page 13, line 13; figures 2A,2B,3A,3B ----	13,14
A	US 4 820 952 A (LEE KYE S) 11 April 1989 (1989-04-11) the whole document ----	1
P,X	WO 99 65274 A (NEW TRANSDUCERS LTD ;BANK GRAHAM (GB)) 16 December 1999 (1999-12-16) the whole document -----	1,3

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Information on patent family members

International Application No

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